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HEMOGLOBIN DATA IN DHS SURVEYS: INTRINSIC VARIATION AND MEASUREMENT ERROR

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Hemoglobin Data in DHS Surveys: Intrinsic Variation and Measurement Error

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Preface

The Demographic and Health Surveys (DHS) Program is one of the principal sources of international data on fertility, family planning, maternal and child health, nutrition, mortality, environmental health, HIV/AIDS, malaria, and provision of health services.

One of the objectives of The DHS Program is to continually assess and improve the methodology and procedures used to carry out national-level surveys as well as to offer additional tools for analysis. Improvements in methods used will enhance the accuracy and depth of information collected by The DHS Program and relied on by policymakers and program managers in low- and middle-income countries.

While data quality is a main topic of the DHS Methodological Reports series, the reports also examine issues of sampling, questionnaire comparability, survey procedures, and methodological approaches. The topics explored in this series are selected by The DHS Program in consultation with the U.S. Agency for International Development.

It is hoped that the DHS Methodological Reports will be useful to researchers, policymakers, and survey specialists, particularly those engaged in work in low- and middle-income countries, and will be used to enhance the quality and analysis of survey data.

Sunita Kishor

Director, The DHS Program

Abstract

The accurate estimation of anemia is important for tracking and targeting public health interventions. The primary source of anemia data in low and middle-income countries is The Demographic and Health Surveys Program, in which hemoglobin is assessed with a portable hemoglobinometer. This methodological report examines measurement error of hemoglobin assessment and the intrinsic variation in hemoglobin concentrations among children (age 6-59 months), nonpregnant women of reproductive age (age 15-49), and men (age 15 and above). A total of 80 surveys in The Demographic and Health Surveys Program conducted between 2000 and 2016 have been selected, resulting in a total of 1,247,942 hemoglobin observations (405,731 children, 607,101 women, and 235,110 men). Data quality was assessed by examining potential bias in the sub-sampling strategy, outliers, data completeness, and digit preference. Dispersion of the hemoglobin concentrations, which is a combination of measurement error and intrinsic variation, was also explored.

Little bias was found in the situations where hemoglobin measurements are only taken on a sub-sample of the population, although in a few surveys there is a slight bias by urban/rural residence, wealth, or the level of education of the household head. A small percentage of data are missing (the average percentage of missing data was 4.5% for women, 7.1% for children, and 15% for men). There are very few outliers, or values outside of plausible ranges (the average percentage across surveys ranged from 0.1% to 0.2%, depending on the subpopulation). Some preference is observed for the digit 0 (13% of surveys for children, 12% for women, and 7% for men) and digit 2 (14% of surveys for children, 6% for women, and 7% for men), with an avoidance of digits 6 through 9 (28% of surveys for children, 14% for women, and 22% for men).

Standard deviations are outside the range of 1.1 to 1.5 in many surveys for children (46% of surveys excluding implausible values, versus 59% including implausible values); women (71% surveys excluding implausible values, versus 82% including implausible values); and men (96% surveys excluding implausible values and 96% including implausible values). In many surveys the distributions are not normal, especially among adults. Hemoglobin concentrations are higher in urban regions and wealthy populations, and in these groups there was less dispersion, skewness, and kurtosis.

In conclusion, our findings indicate that the overall quality of data is high on some measures, but there are exceptions, especially in terms of wide standard deviations. Disentangling measurement error from intrinsic variation is difficult. Future research is needed to establish standard parameters that assess measurement error in the assessment of hemoglobin and other biomarkers.

KEY WORDS: Anemia, biomarkers, blood collection, data quality, Demographic and Health Surveys, hemoglobin, nutrition

1. Introduction

1.1. Background

Anemia is a widespread public health problem that increases morbidity and mortality, especially among women and children (Balarajan, Ramakrishnan, Ozaltin, Shankar, and Subramanian 2011; Stevens et al. 2013). Anemia, which is defined by a hemoglobin concentration below a certain threshold, is caused by factors that affect the morphology, production, turnover, loss, or destruction of red blood cells (Balarajan et al. 2011). Although iron deficiency is considered the most common cause of anemia around the globe (Engle-Stone et al. 2017; Wirth et al. 2017), there is an growing recognition that iron deficiency is not the driving cause of anemia in all settings (Petry et al. 2016). Other major contributors include mineral and vitamin deficiencies other than iron deficiency, acute and chronic inflammation, parasitic infections, and acquired or inherited disorders (Kassebaum et al. 2014).

The multifactorial nature of anemia and the challenges in implementing interventions to address these factors have resulted in few countries being able to successfully curb the high prevalence of anemia (International Food Policy Research Institute 2016). As a result, anemia has been prioritized as one of seven nutrition indicators selected for inclusion in the World Health Assembly targets (WHO and 1000 Days 2014). Anemia data are important for monitoring progress toward meeting international goals and advocating for appropriate action in populations at greatest risk. Thus, precise, accurate, and reliable measurement is critical to inform the prevention and control of anemia.

The World Health Organization (WHO) recommends the use of hemoglobin as the biomarker to determine the population-based prevalence of anemia (WHO 2011). The reference method for the measurement of hemoglobin is the hemoglobincyanide (HiCN) method of the International Council for Standardization in Hematology (Zwart et al. 1996). This method, or a method based on the HiCN principle, has been automated for use in hospitals, health facilities with large patient populations, and reference laboratories. In population-based surveys, the Hemocue® (HemoCue AB, Angelholm, Sweden) is routinely used to measure hemoglobin and is recommended by the WHO (WHO 2001). This device is relatively inexpensive, easily portable, does not require a cold chain, and produces a result within a minute. A Hemocue® device is generally considered to be capable of providing precise and accurate measurements of hemoglobin concentrations (Cohen and Seidl-Friedman 1988). However, results can be compromised during blood collection from "milking" of the finger, using the incorrect blood volume in the microcuvette, or not properly cleaning the microcuvette (Karakochuk).

1.2. Objectives

In July 2016, with the support of USAID, the PATH HealthTech program organized an expert consultation meeting on "Hemoglobin testing methods: Research and program implications". The meeting's objectives were to share experiences performing hemoglobin measurements in large surveys and to discuss challenges and opportunities. Data presented at the meeting and discussions among the participants identified multiple sources of variation in hemoglobin measurements, which arise from blood sampling procedures and conditions (e.g. wicking versus gravity), the use of different HemoCue® models and devices, and biological factors (e.g. genetic variations). It was also noted that the extent of variability in hemoglobin measurements may be higher for younger children, compared to older children, and there may be less variability of hemoglobin measurements among adults, compared to children.

The findings from the meeting suggested a need to further explore variations in hemoglobin concentration and the quality of hemoglobin measurement in population-based surveys. The following two activities were proposed, with this report addressing the second:

1. Create a collaborative group to examine the existing data on hemoglobin assessments from the countries discussed at the expert consultation (including Cambodia, Laos, Rwanda, Mexico, and Guatemala).
2. Conduct an in-depth analysis of hemoglobin measurements with data from The Demographic and Health Surveys (DHS) Program.

The first objective of this methodological report is to assess errors of measurement. The second objective is to use the large accumulation of DHS survey data to describe intrinsic variation in hemoglobin levels across and within a wide range of populations and subpopulations. "Intrinsic" variation refers to the true or underlying levels and distributions of hemoglobin.

Strategies for analyzing data, which assume that errors of measurement are negligible, and strategies for detecting errors of measurement, which assume that they are *not* negligible, are often similar. For an individual respondent, the recorded measurement can be expressed as a sum of three terms that include the population mean, the individual's deviation from the population mean, and a disturbance or error, which potentially includes measurement error. If there are measurement errors, either random or systematic, they will be confounded with true individual-level deviations from the population mean. It is not possible to disentangle true variation and measurement error for specific individuals, but if there is measurement error then the overall distribution will tend to be over-dispersed, leading to over-estimation of the proportion of the population with anemia, particularly with severe anemia. If the distribution is skewed, the median may be preferable to the mean as a summary measure, and this report includes medians as well as means. The magnitude of error may be associated with some characteristic such as age. We will provide some generalizations about the underlying distributions of hemoglobin levels; will identify some surveys that probably, if not definitively, had measurement issues; and will use some indicators of data quality that could be applied to future surveys, even during data collection.

2. Procedures, Data, and Methods

2.1. Procedures

2.1.2. Hemoglobin measurement in The DHS Program

DHS surveys frequently include the measurement of hemoglobin. In the DHS surveys, when hemoglobin is included, the subpopulation of primary interest is children age 6-59 months. Most surveys that include hemoglobin measurement for children also include measurements for women age 15-49, and about one-third of such surveys also include men age 15 and older. Hemoglobin measurement is included in all the Malaria Indicator Surveys (MIS), but only for children. The DHS Program generally does not measure hemoglobin in children age 5-14.

The protocol for hemoglobin assessment has remained relatively consistent since testing was first introduced into The DHS Program in 1996. Hemoglobin concentrations are measured in a small volume of capillary blood with the HemoCue 201+ or the 301+ system[1]. Blood is obtained from a finger for adults and for children age 12-59 months and from the heel of children age 6-11 months. In early surveys, blood was sometimes obtained from the finger of children younger than age 12 months.

The skin is warmed by rubbing the hands or heel to increase blood flow. The hand or heel is placed below the level of the heart, and the finger or heel is then cleaned thoroughly with alcohol. With a finger prick, the data collector is trained to select the third or fourth finger, use a rolling movement of the thumb to lightly press the finger from the top knuckle toward the tip, and maintain a gentle pressure to trap the blood. With a heel prick, the data collector is trained to apply light pressure around the heel. The skin is cleaned and then pricked with a sterile, retractable lancet to obtain the blood sample.

Table 2.1.1 Blood drop used to obtain hemoglobin measurement

Blood drop	Biomarkers measured in survey
Third	Hemoglobin only
Fourth	Hemoglobin and malaria
Fifth	Hemoglobin and dried blood spot

In general, after the first two free-flowing blood drops are wiped away with a sterile piece of gauze, the third blood drop is sampled with the microcuvette. The fourth or fifth drop of blood is sometimes used for hemoglobin measurements when other biomarkers are being tested (see Table 2.1.1.). The blood drop is placed in the microcuvette directly from the finger or heel without touching the finger or heel. The data collector must ensure that the microcuvette is completely filled with no air bubbles. The outside of the microcuvette is cleaned and then inserted into the photometer, which generates a result within a minute and allows for the immediate return of results to survey participants. Participants are provided with a referral

[1] The principles used for the HemoCue system to determine hemoglobin concentration are: HemoCue 201+ "The erythrocyte membranes are disintegrated by sodium deoxycholate, releasing the hemoglobin. Sodium nitrite converts the hemoglobin iron from the ferrous to the ferric state to form methemoglobin, which then combines with azide to form azidmethemoglobin. The photometer uses a double wavelength measuring method, 570 nm and 880 nm, for compensation of turbidity." HemoCue 301+ "Measures the absorbance of whole blood at an Hb/HbO2 isobestic point. The analyzer uses a double wavelength measuring method, 506 nm and 880 nm, for compensation of turbidity." Obtained from http://hemocuelearningcenter.com/hemoglobin-product-specifications/.

slip for follow-up medical attention if their hemoglobin concentration is low[2]. The data collector records the hemoglobin concentration in grams per deciliter (g/dL).

2.1.3. Classifying anemia in DHS surveys

The cutoffs in Table 2.1.2 are applied to hemoglobin concentrations in DHS surveys to obtain population-level estimates of anemia. Hemoglobin concentrations are first adjusted for altitude and cigarette smoking because both tend to increase hemoglobin concentrations[3] (World Health Organization and Centers for Disease Control and Prevention 2007). For persons living more than 1000 meters above sea level, altitude is adjusted by adding $0.32A-0.22A^2$, where A is the altitude in feet (the altitude in meters multiplied by 0.0033). The adjustment is negative, as shown in Figure 2.1.1.[2] (Nestel P and The INACG Steering Committee 2002). Pre-established values are subtracted from observed hemoglobin concentrations among smokers, depending on the number of cigarettes smoked per day. If the number is less than 10, there is no adjustment; for 10-19, 0.3 g/dL is subtracted; for 20-39 cigarettes, 0.5 is subtracted; and for 40 or more cigarettes, 0.7 is subtracted. If the person smokes cigarettes but the number is unknown, 0.3 g/dL is subtracted (Nestel P and The INACG Steering Committee 2002)[4].

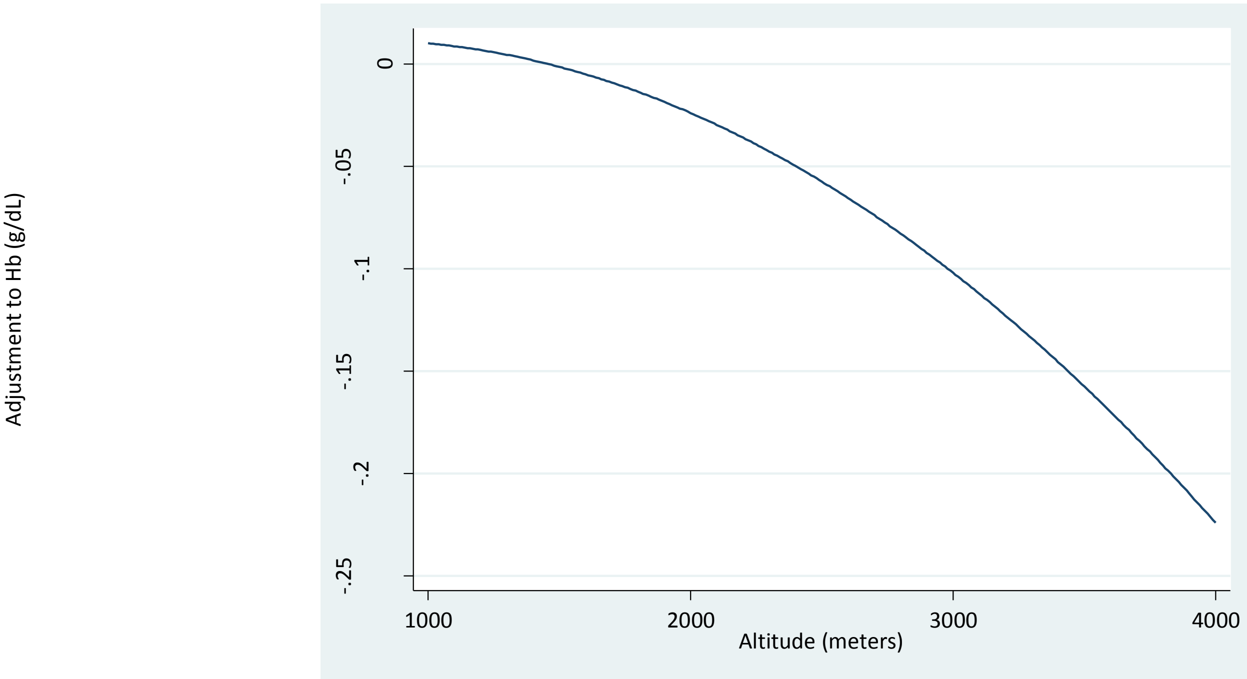
Table 2.1.2 Hemoglobin cutoffs used in The DHS program to define anemia at sea level.

	Anemia measured by hemoglobin (g/dL)*			
	Any Anemia	Mild	Moderate	Severe
Children age 6- 59 months[1]	<11.0	10.0- 10.9	7.0- 9.9	<7.0
Nonpregnant women age 15-49[2]	<12.0	10.0- 11.9	7.0- 9.9	<7.0
Men age 15 and above	<13.0	11.0- 12. 9	8.0- 10.9	<8.0

[1] Malaria Indicator Surveys defines severe anemia as <8.0 g/dL
[2] World Health Organization recommends slightly modified hemoglobin cutoffs to define anemia for nonpregnant women: mild anemia (11.0-11.9 g/dL), moderate anemia (8.0-10.9 g/dL), and severe anemia (<8.0 g/dL).

[2] While it can vary between surveys, children and non-pregnant women (or women whose pregnancy status is unknown) are generally referred when their hemoglobin concentration is less than 7.0 g/dL in DHS and 8.0 g/dL in MIS. Pregnant women, and men, are referred when the hemoglobin concentration is less than 9.0 g/dL. The hemoglobin concentration cutoffs used for referral purposes by The DHS Program differ from the WHO classification of severe anemia.
[3] Some early surveys were not adjusted for altitude or were adjusted at altitudes below 1000 meters.
[4] Until recently, cigarette consumption in some surveys adjusted hemoglobin concentrations by -0.3 g/dL for participants reporting cigar and pipe smoking behaviors.

Figure 2.1.1 Additive adjustment to hemoglobin concentrations g/dL for altitudes greater than 1000 meters



2.2. Data

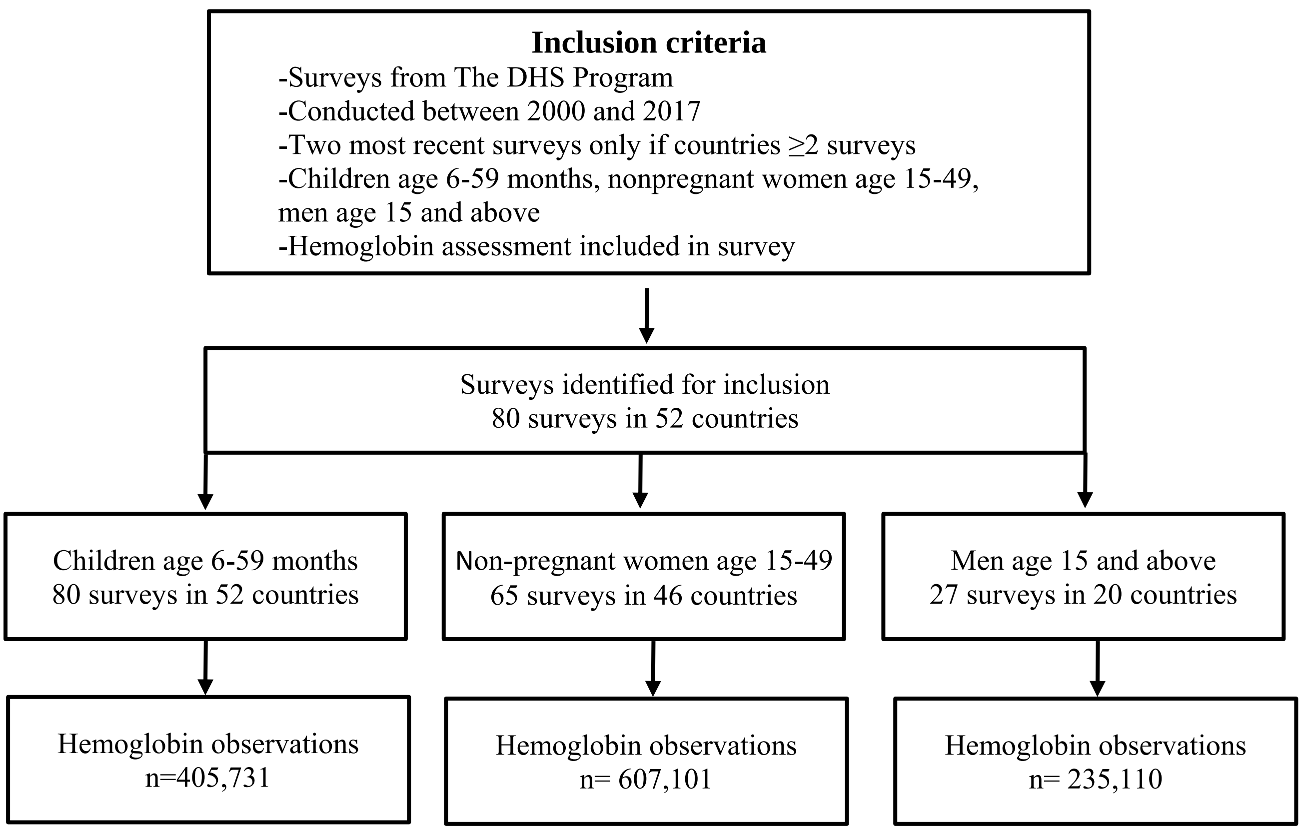
2.2.1. Surveys included in the analysis

The DHS surveys, including MIS surveys, are nationally representative. Eighty surveys have been selected for inclusion in this report (Figure 2.2.1). Twenty-four countries are represented with one survey and 28 countries with two surveys. Of the 80 surveys, 53 surveys are from 33 countries in the African Region, 10 surveys from 6 countries in the Region of the Americas, 6 surveys from 5 countries in the South-East Asia Region, 4 surveys from 4 countries in the European Region, 5 surveys from 4 countries in the Eastern Mediterranean Region, and 2 surveys from 1 country in the West Pacific Region based on the WHO definition of regions. The surveys are listed in Appendix 1. They comprise all DHS and MIS surveys since 2000 that included hemoglobin measurements, except that if a country had more than two such surveys, only the two most recent surveys are included.

When the measurements are made in the field as part of data collection for the entire household, there is no distinction between de facto (slept in the household last night) and de jure (usual) residence. In all surveys, the vast majority of respondents satisfy both definitions, although in every survey there are some residents who satisfy one definition but not the other, usually approximately the same number for each of the two possibilities. The DHS main reports generally limit estimates to de facto residents. In this report, however, we restrict the analysis to de jure observations because an altitude adjustment based on current location could be inappropriate for someone who normally resides elsewhere. This resulted in the removal of 2.5% of the total observations for children, 2.9% of women, and 2.3% of men.

Data are included for children age 6-59 completed months, non-pregnant women 15-49 completed years of age, and men 15 completed years of age and above (the upper end of the age range varies across the surveys of men). Women who state that they are currently pregnant are excluded (9.5% of the total hemoglobin observations for women) because hemoglobin concentrations may depend on the trimester of pregnancy. No distinction was made between lactating and non-lactating women. Although the age range of eligibility for children is age 6-59 months, we found some measurements for children younger than age 6 months. These children were excluded from further analysis (5.9% of the total hemoglobin observations for children were removed). A total of 1,247,942 hemoglobin observations are included in this analysis (Figure 2.2.1). This total reflects all de jure participants selected for hemoglobin measurement that met our subpopulation inclusion criteria.

Figure 2.2.1 Sample size flow chart



2.2.2. Definitions of hemoglobin and other variables used in this analysis

This analysis uses the DHS household standard recode file for each survey, referred to as the "person records (PR)" file. Table 2.2.1 summarizes the variables in this analysis. Hemoglobin concentrations, whether unadjusted or adjusted for smoking and altitude (when applicable), are presented in g/dL. Adjustments for altitude and smoking are made during the preparation of the recode files. In this report, it was assumed the adjustments for smoking and altitude were done correctly, using self-reports of tobacco use and the altitude at the centroid of the sample cluster measured during data collection. Anemia categories, as shown in Table 2.1.2., are defined after adjusting for altitude and smoking, as applicable. Values at a boundary are classified into the category with the higher number. For example, children with a hemoglobin concentration of 11 g/dL, along with children who have a higher level, are classified as “not anemic”. In this report, the only use of anemia categories will be shown in the shading of categories in figures that show the distribution of hemoglobin.

Table 2.2.1 Summary of variables used in the analysis from the person records (PR) file[1]

Name	Definition	Code	Notes
HV042	Household selected for hemoglobin	1: selected; 0: not selected	Some surveys subsampled households for hemoglobin testing; some surveys included testing in all households.
HA52 HB52 HC52	Read consent statement	1: granted; 2: Parent/other responsible [adult] refused; 3: respondent refused; 9: Missing; NA: not applicable	Some surveys have other numeric values that are also interpreted as “permission not granted”.
HA53 HB53 HC53	Hemoglobin unadjusted	g/dL with one implied decimal 994: Not Present; 995: Refused; 996: Other; 999: missing; NA: not applicable	The data files have one implied decimal; values were divided by 10 to be interpretable as g/dL. Missing codes varied in some surveys.
HA56 HB56 HC56	Hemoglobin adjusted[5]	g/dL with one implied decimal 999: missing; NA: not applicable	Adjusted for altitude and smoking among women and men and for altitude among children; adjusted concentrations are in g/dL.
HA1 HB1 HC1	Age of respondent	Months for children and years for adults	
HV024	Region of residence	Codes are country-specific	
HV025	Type of place of residence	1: urban; 2: rural	
HV106	Respondent’s education	0: No education; 1: Primary; 2: Secondary; and 3: Higher	Education of household head is obtained for the person in the household with HV101 (Relation to Household Head) equal to 1 (Head). Secondary and higher education are combined when defining education of head of household but not when defining women respondent’s education in this report.
HV270	Wealth Index	1: lowest; 2: second; 3: middle; 4: fourth; 5: highest	A summary scale based on household assets, divided into quintiles.

[1] HV indicates a household variable; HA refers to women, HB to men, and HC to children; A blank (or “.” in Stata) is used for “not applicable” or “not eligible”. Cases receive this code if they are outside the applicable combination of age and sex, or if there is subsampling and their household is not included in the hemoglobin subsample.

2.3. Methods

2.3.1. Methods of analysis

Estimates in the DHS reports are weighted in order to compensate for over- and under-sampling of the various strata in a survey and differential nonresponse. In this report, our focus is on individual measurements and not population estimates. Therefore, all calculations are unweighted. DHS does not flag and exclude biologically implausible hemoglobin concentrations, although for the purposes of this report, biologically implausible values were defined as hemoglobin concentrations outside of the range of 4.0 g/dL to 18.0 g/dL for children and women, and 5.0 g/dL to 20.0 g/dL for men (Sullivan, Mei, Grummer-Strawn, and Parvanta 2008).

A. Representative subsampling

Hemoglobin measurements usually apply to all households, although they are sometimes restricted to a subsample of households. In surveys that collected hemoglobin measurements in a subset of households, it is important to be confident that those households were randomly selected. To assess this, we first identified the surveys where subsampling was undertaken and calculated the fraction of households subsampled. Second, we tested whether, when there is subsampling, those households are randomly selected with respect to four covariates. We conducted logit regressions in which the outcome was 1 if the household was selected, 0 if it was not. The covariates were urban/rural residence, region, education of the household head (no education, primary, secondary and above), and wealth quintiles.[1] The logit regression produces a maximum likelihood chi-square statistic that can test the statistical significance of the model. If the selection was significantly associated with a covariate, we infer that the selection was not random with respect to that covariate.

B. Completeness of data

The criterion of "completeness" refers to low levels of "missing" observations or measurements that are outside a plausible range. The main coded reasons for not being measured, although eligible for measurement, are that the person was not present at the time of the measurements, or was present and refused consent to be measured. In the case of a child, it is the parent who must provide consent. There is also an "other" category, which is not specific as to the reason why the person was not measured. In addition, we identified the percentage of participants with values outside the biologically plausible ranges.

C. Digit preference

Digit preference was examined to assess whether the distribution of final digits of the hemoglobin measurement had a uniform distribution. A tendency for some final digits such as 0 to be reported more often than expected (more than 10% of the time), and other digits to be reported less often than expected may suggest the improper use of equipment or carelessness. The digit to the right of the decimal place, on a g/dL scale, was used to examine digit preference. This part of the analysis used the unadjusted hemoglobin measurements and included observations with biologically implausible values.

D. Distribution of hemoglobin concentrations

We first examine the distribution of hemoglobin concentrations with the mean, median, range, and standard deviation. If measurement errors occur randomly, then the observed variance (the square of the observed standard deviation) is equal to the sum of the true variance and the variance of the measurement error. A relatively large standard deviation may indicate poorer quality data. A very small standard deviation may also suggest inaccurate measurement. Following Sullivan et al. (2008), standard deviations between 1.1 and 1.5, inclusive, were considered to be acceptable. Standard deviations less than 1.1 and greater than 1.5 were identified. Standard deviations are calculated for hemoglobin concentrations adjusted for altitude and smoking, as applicable, both including and excluding the hemoglobin concentrations that were biologically implausible. We also plotted the standard deviation against the mean, after excluding biologically implausible hemoglobin concentrations.

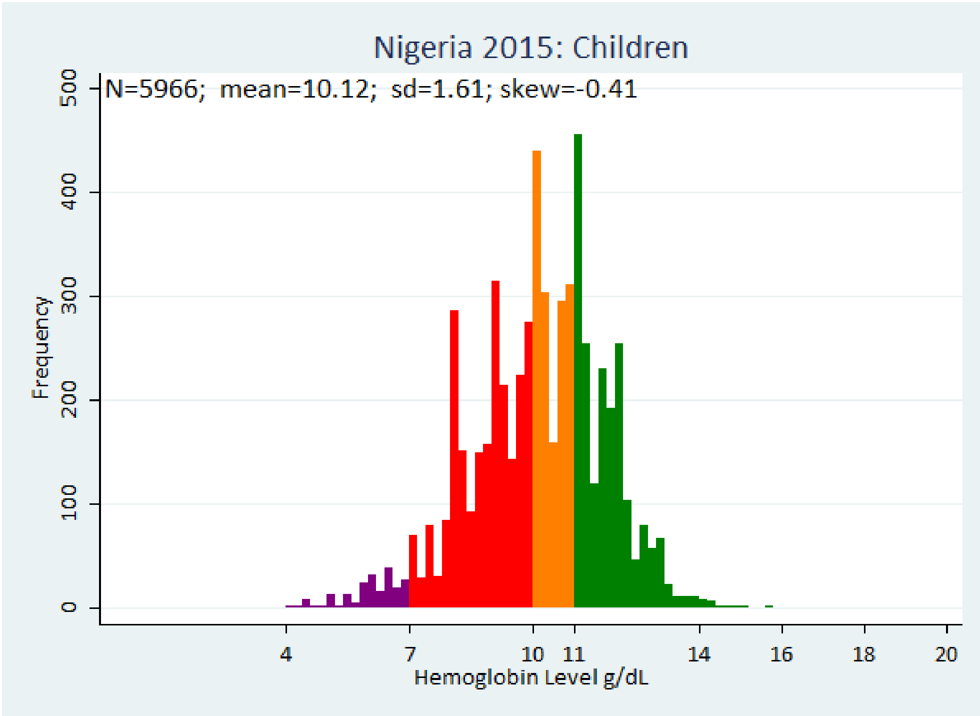
The shape of the distribution of hemoglobin concentrations is described in terms of skew and kurtosis. The reference values for the skew and kurtosis will be those of a normal distribution, 0 and 3, respectively. Skew measures asymmetry. It is positive, and the distribution is right-skewed, if there are more extreme cases in the right tail than the left tail. It is negative, and the distribution is skewed to the left, if the left tail dominates. Kurtosis is greater than 3 if there are many extreme values in the tails, relative to a normal distribution; it is less than 3 if the tails are relatively short. A general rule of thumb for an "acceptable" range of skew is from -0.5 to 0.5 and an "acceptable" range for kurtosis is from 2 to 4; subpopulations outside of this range are identified. We explicitly do not assume that the "true values" are normally distributed, and only use a normal distribution as a reference. The skew and kurtosis are calculated with and without the inclusion of biologically implausible values. In both cases, hemoglobin concentrations are adjusted for altitude and smoking as applicable.

We examined the mean, median, standard deviation, skew, and kurtosis stratified by several covariates for women and children, the populations of greatest public health relevance. For women, the covariates include (a) age, with intervals 15-19, 20-34, and 35-49; (b) urban and rural residence; (c) level of education (none, primary, secondary, higher); and (d) wealth quintiles. For children, the analysis will be repeated for (a) age, with intervals 6-11 months, 12-23 months, and 24-59 months; (b) urban and rural residence; (c) boys and girls; and (d) wealth quintiles. Differentials for men are not included; it is assumed that any would mirror those found for women. Differentials are presented with the exclusion of biologically implausible hemoglobin concentrations, and with adjustments for altitude and smoking as applicable.

The report includes some figures that show the distribution of hemoglobin concentrations in selected surveys and subpopulations. Figure 2.3.1 is an example. The Nigeria 2015 survey is the selected example because it is a recent survey from one of the largest countries in which DHS works. The top of the figure shows the number of cases in the range from 4 to 18 g/dL, as well as the mean, standard deviation, and skew of the distribution. The purple, red, orange, and green segments represent severe, moderate, mild, and no anemia, respectively[5]. The vertical bars have a width of 0.2 g/dL. The conspicuous spikes in the histogram are due to heaping at numerical values ending with ".0" in this survey. As noted above, at a boundary, those values are classified with the higher category (to the right) rather than with the lower category. Figures such as Figure 2.3.1 exclude biologically implausible values and refer to the concentrations adjusted for altitude and smoking as applicable.

[5] Standard DHS cutoffs for hemoglobin concentrations are used.

Figure 2.3.1 Illustration of the distribution of the hemoglobin level for children age 6-59 months, Nigeria 2015



3. Results: Indicators of Data Quality

This chapter presents a review of data quality using three indicators. First, we examine evidence of potential selection bias in surveys where hemoglobin measurements were only obtained from a subsample of survey participants. Second, we assess the level of data completeness, defined by the percentage of hemoglobin measurements that are missing or are outside of a biologically plausible range. Third, we calculate the extent of under- or over-reporting of specific final digits.

3.1. Representativeness of subsampling

Eligibility of individuals for hemoglobin measurement is determined at the level of the household. If the household is selected, then all children, women, or men in that household will be selected, so long as they are in the appropriate age range and the measurements extend to women and men. In some surveys, all households were eligible for hemoglobin measurement, but in some surveys a subsample was selected. Of the 80 surveys in this analysis, 35 did not, and 45 did involve subsampling. Subsampling generally takes the form of selecting alternate households in the household listing within a cluster, or selecting one in three, or (least often) skipping one in three and selecting the other two. Some variation around the target sampling fractions (one-third, one-half, and two-thirds) is a normal consequence of sampling[6]. This strategy should be random with respect to any characteristic of the household or its members.

Table 3.1.1 lists the 45 surveys that involved subsampling and the percentage of the subsample selected for hemoglobin measurement (based on variable HV042). Eleven surveys had approximately one-third of households selected for hemoglobin measurements from the total sampled population (31.9% to 35.1%); 30 surveys had approximately one-half of households selected (47.8% to 51.9%); and 4 had two-thirds of households selected (64.8% to 66.7%).

The *p*-values of the logit regression selected for hemoglobin measurement as the outcome and potential selection bias variables as the covariates are shown in Table 3.1.1 The level of statistical significance is indicated with adjacent columns including asterisks: * indicates $p<.05$, ** indicates $p<.01$, and *** indicates $p<.001$. Based on the large number of tests described in the table, we would expect approximately 9 cells with at least one asterisk, 2 cells with at least two asterisks, but no cells with three asterisks. We observed 7 cells with one asterisk, 6 cells with two asterisks, and 1 cell with three asterisks.

The greatest evidence of selectivity was related to the education of the household head, especially in the Bangladesh 2011 survey, which was large, with 17,141 households, of which 5,754 or 33.6% were selected for hemoglobin measurement. The observed sampling fractions were 32.0% if the household head had no schooling, 35.0% if he/she had primary schooling, and 33.3% if he/she had secondary or higher education. These three sampling fractions are significantly different from one another, although the differences are not substantively large and the sampling fractions do not increase or decrease monotonically with increases in education.

It is notable that not a single survey showed significant variation—that is, evidence of nonrandom selection—across regions. Only one survey, Cambodia 2011, showed evidence of selectivity on more than

[6] Even a simple even/odd procedure will produce a deviation from exactly half of households being selected, because of randomness in whether the number of interviewed households in a cluster is even or odd.

one of the four covariates. The Cambodia 2011 survey had a test statistic that is significant at the 0.01 level on both urban/rural residence and education of the household head. This survey had 15,825 households, of which 10,275, or 64.9%, were selected for hemoglobin measurement. The observed sampling fractions for urban and rural areas were 66.8% and 64.2%, respectively, and were 66.8%, 63.6%, and 65.9%, respectively, for the three levels of education of the household head.

Table 3.1.1 Tests of the randomness of household selection for hemoglobin measurement, by covariates

Survey	Sampling fraction (%)	Residence p-value	Region p-value	Education p-value	Wealth p-value
Angola 2011	32.5	0.78	0.95	NA	0.71
Angola 2015-16	50	0.97	1	0.53	0.57
Bangladesh 2011	33.6	0.83	1	0.00***	0.73
Benin 2006	33.3	0.85	1	0.07	0.17
Benin 2011-12	33.1	0.94	1	0.52	0.08
Bolivia 2003	35.1	0.81	1	0.01**	0.88
Bolivia 2008	34.9	0.89	1	0.00**	0.54
Burkina Faso 2010	49.9	0.86	1	0.51	0.02*
Burundi 2010	50	0.64	1	0.25	0.91
Cambodia 2010	49.9	0.92	1	0.18	0.61
Cambodia 2014	64.9	0.00**	1	0.00**	0.52
Cameroon 2004	50.8	0.47	1	0.49	0.47
Cameroon 2011	50.1	0.97	1	0.89	1
Congo DR 2007	50	0.99	1	0.43	0.71
Congo DR 2013-14	50	0.89	1	0.95	0.7
Congo 2005	50	0.83	1	0.42	0.13
Congo 2011-12	50	0.94	1	0.89	0.82
Cote d'Ivoire 2011-12	50.5	0.41	1	0.85	0.73
Egypt 2014	33.6	0.72	1	0.16	0.21
Gabon 2012	66.6	0.96	1	0.38	0.3
Gambia 2013	47.9	0.76	0.99	0.59	0.18
Ghana 2014	50.1	0.82	1	0.83	0.9
Guinea 2005	49.8	0.91	1	0.88	0.57
Guinea 2012	49.9	0.7	1	0.79	0.83
Haiti 2005-06	49.6	0.88	1	0.6	0.09
Haiti 2012	66.7	0.94	1	0.84	0.82
Jordan 2009	49.5	0.77	0.94	0.68	0.00**
Jordan 2012	64.8	1	0.94	0.81	0.29
Lesotho 2009	51.9	0.77	1	0.96	0.44
Lesotho 2014	49.8	0.57	0.99	0.49	0.38
Malawi 2015-16	33.3	0.78	0.94	0.02*	0.14
Mali 2012-13	49.9	0.72	1	0.5	0.3
Mozambique 2011	50	0.88	1	0.23	0.7
Namibia 2013	49.9	0.45	1	0.93	0.11
Nepal 2011	48.9	0.28	0.96	0.02*	0.67
Niger 2006	49.8	0.86	1	0.17	0.02*
Niger 2012	47.8	0.86	0.98	0**	0.4
Rwanda 2010	50	0.93	1	0.03*	0.15
Rwanda 2014-15	50	0.96	1	0.19	0.05*
Sierra Leone 2008	50	0.78	0.97	0.87	0.14
Sierra Leone 2013	50	0.79	1	0.41	0.23
Timor-Leste 2009-10	33.4	0.94	1	0.22	0.79
Togo 2013-14	49.8	0.9	1	0.15	0.2
Uganda 2011	31.9	0.99	1	0.01*	0.47
Yemen 2013	32	0.96	1	NA	0.59

Note: Congo DR, Congo Democratic Republic; residence defined as urban or rural; region definition varied by survey; education defined as head of household received no education, primary, secondary or above; wealth defined as wealth quintiles; significance of selectivity in selection is indicated by * for .05 level, ** for .01 level, *** for .001 level.

3.2. Data completeness

Table 3.2.1 presents information on data completeness. Overall the percentage of valid data was high, with a small percentage of missing data and hemoglobin measurements outside of the biologically implausible ranges.

The average percentage of missing responses is similar for children and women, 7.1% and 4.5%, respectively, and higher for men, 15.0%. There are specific surveys in which the percentage is much higher, especially for children. There are some inconsistencies in the codes for incomplete or missing responses. There are a few surveys where the consent variable indicates that consent was not obtained but there is a hemoglobin measurement. Such inconsistencies are most likely data entry errors or instances in which a person was not initially available, a code to that effect was entered, the person became available, and the consent code was not updated. There are two surveys in which the unadjusted measurements (H*53) are included but the adjusted variables (H*56) are absent. These are surveys in which the smoking questions were omitted and altitudes never exceeded 1000 meters. The unadjusted values should have been copied directly, with no changes, during data processing, but were not. In addition, there are some variations in the use of the standard DHS codes to indicate missing values. A total of 19 of the surveys used the missing value codes 994, 995, 996, and 999 for the unadjusted hemoglobin measurement variable (H*53). Of the remainder, 29 surveys used 994, 995, 996 and not 999, and 26 surveys used only 999. One survey used 800 to indicate missing values. In 5 surveys (Angola 2011, Bolivia 2003, Cambodia 2014, Lesotho 2009, and Nepal 2006) there were no missing values at all. An examination of the data suggests that the children who should have been assigned a "missing" code were actually given the "not applicable" code, which is a blank. For example, there are identifiable children whose mother was excluded (and given codes 994, 995, or 996) and the child was not measured (probably for the same reason as the mother) and the child was given the "not applicable" code (a blank) rather than the same missing value code as the mother. This kind of confounding of "missing" and "not applicable" is contrary to normal DHS practice.

The percentage of measurements that are numeric but outside the plausible ranges is always below 0.8%. However, the out-of-range values can have a substantial effect on summary statistics, because they can be extremely large. An example from one of the surveys is a single case with a value of 880 (with one implied decimal place), which converts to a hemoglobin concentration of 88.0. The value 880 is almost certainly a data entry error, for a concentration of either 8.0 or 8.8. Some of the out-of-range values are simply 0. Most of the out-of-range values are likely the result of data entry errors, such as entering a spurious leading digit or final digit, or dropping the leading digit or final digit. Data entry errors can also lead to an incorrect value that is in-range, no matter how the plausible range is defined, and be impossible to detect.

Table 3.2.1 The percentage of valid, implausible, and missing hemoglobin data

	Children (age 6-59 months)		Women of Reproductive Age (15-49)		Men (age 15 and above)	
	Mean %	Range	Mean %	Range	Mean %	Range
Missing[1]	7.1%	0.0-53.9%	4.5%	0.0-17.5%	15.0%	0.6-35.3%
Implausible	0.2%	0.0-0.7%	0.1%	0.0-0.8%	0.1%	0.0-0.5%
Valid	92.8%	46.0-100.0%	95.4%	82.4-100.0%	84.9%	64.6-99.3%

Note: Total sample is defined de jure participant selected for hemoglobin measurement; percentage of missing values is based on total sample; Final sample is defined as total sample minus respondents with missing hemoglobin measurements available; percentage of implausible values is based on final sample. Percentage of valid values reflects the total sample without missing and implausible values. Implausible values defined as hemoglobin values outside of 4 g/dL to 18 g/dL for children and nonpregnant women and 4 g/dL to 20 g/dL for men after adjusting for altitude and smoking when applicable.

[1] In the data file for the Congo 2005 survey, for children only, the missing value code "999" was assigned to children who were not measured because their household was not in the subsample selected for hemoglobin measurement. Such children should have received a "blank" code for "not applicable". This error was made during the construction of the public use data files and we could not correct it. If that error is taken into account, the correct level of missing was 11.2%, rather than 53.9%.

3.3. Digit preference

A common indicator of data quality in various contexts is a tendency for certain final digits to appear more often than expected by chance. The most familiar example is age heaping, in which ages of adults are disproportionately given with final digit 0 and, to a lesser extent, with final digit 5. Heaping of ages is usually the result of respondents not knowing their actual ages. In the present context, rounding or other forms of unevenness in the distributions of digits would suggest carelessness by the person making the readings.

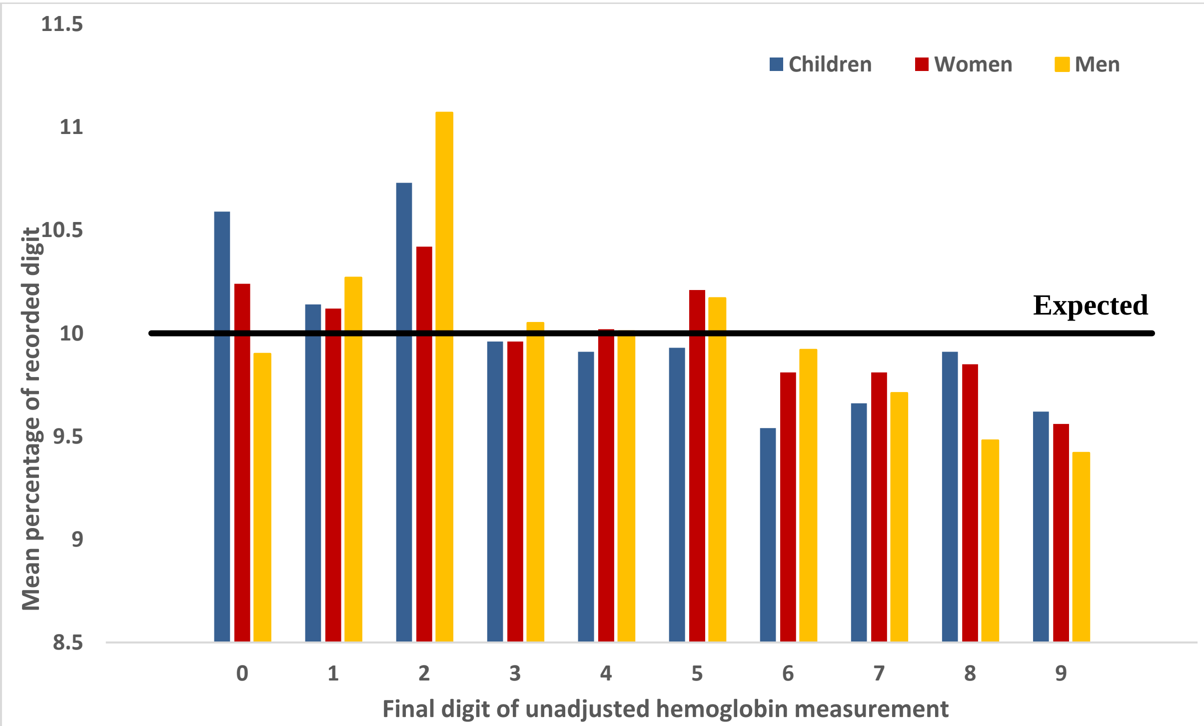
Figure 3.3.1 summarizes the variation in final digits across surveys and subpopulations. Note that the vertical axis is limited to a narrow range between 8.5% and 11.5%. We would expect each of the ten possible values (0 through 9) to occur in approximately 10% of the cases. On average, the observed percentage for each digit ranges from 9.4% to 11.1%. The distribution is close to uniform, but the results lead to specific examination of digits 0, 2, 5, and the range 6-9, and the numbers of surveys in which the observed percentages deviate from the expected percentages by 2% or more (deviations of this magnitude are always statistically significant). The expectation is 10% for digits 0, 2, and 5, and 40% for the range 6-9.

Across the 80 surveys of children and the 65 surveys of women, there are 32 times when the percentage of final digits 0 or 2 is higher than 12%, almost equally favoring final digit 0 and final digit 2. There are only two settings in which the percentage of 0 or 2 is extreme in the lower direction, i.e. is less than 8%. Most conspicuously, for women and children in the Albania 2008-09 survey, the observed occurrence of 0 is much lower than expected, about 5%. This low frequency may be the result of instructions to fieldworkers to avoid heaping at 0, with the result that 0 was avoided even when it was appropriate. It is likely that a much lower than expected occurrence of final digit 5 in the Armenia 2005 survey has the same explanation. Heaping at 5, as well as 0, may have been anticipated during training because of the typical pattern of age heaping, but as it happens the only evidence of preference for final digit 5 is found for women in the Angola 2006-07 and Benin 2011-12 surveys.

A deficit of final digits 6, 7, 8, and 9, collectively, is very conspicuous. This pattern is found with a negative deviation of 2 percentage points or more in 24 of the 80 surveys of children and 12 of the 67 surveys of women. It is apparent that there is a tendency in these surveys for readings that should end in final digits 6, 7, 8, and 9 to be shifted upwards to the next multiple of 10, a shift that would account for the deficit at 6, 7, 8, and 9 and the excess at 0. In the context of age, heaping at multiples of 10 is typically drawn symmetrically from the neighboring digits. For example, an excess reported at age 50 is usually accompanied by deficits at ages 47-49 and 51-53. For the hemoglobin measurements, by contrast, it appears that the shift is not symmetric, but is upwards, potentially raising the mean reading. The mechanism leading to this asymmetric upward shift in some surveys is worth investigating.

To summarize, there is a clear tendency for heaping at final digits 0 and 2 and a deficit at digits 6-9, but these patterns are only found in a minority of surveys. Even for those surveys, the effect on the distributions across categories of anemia will be very small.

Figure 3.3.1 Summary statistics for digit preference for hemoglobin data across surveys by subpopulations



Note: Hemoglobin concentrations are unadjusted for altitude and/or smoking and include implausible values; n=80 (children), 65 (women), 27 (men) surveys; on average we would expect each digit to occur 10 percent of the time +/- 2 percentage points.

4. Results: Intrinsic Variation

This chapter of the report examines the distributions of the hemoglobin measurements within each survey and provides an overview of their variability in terms of central tendency, dispersion, and shape. Central tendency is described with the mean and median. If a distribution is symmetric, these are equal or nearly equal; if a distribution is skewed, the mean will shift away from the median, in the direction of the longer tail (to the left for negative skew or to the right for positive skew). Dispersion is measured with the standard deviation and shape with the skew and kurtosis. For surveys and subpopulations with very low or very high values of these statistics, relative to other surveys and subpopulations, it is reasonable to question whether there may be some distortion due to measurement error. Unusual distributions may occur because a population is unusually healthy, unhealthy, homogeneous, or heterogeneous, with no issues of data quality. Alternatively, distributions may be unusual because of measurement error, which could cause high dispersion or nonrandom measurement error that could cause extreme levels of skew or kurtosis. Because of the possibility of measurement error, we hesitate to state definitively that what is described here—at the extremes—is intrinsic variation. This chapter will allow for an interpretation that the most unusual distributions have been at least somewhat distorted by measurement error, although that inference cannot be conclusive. The contexts in which data collection is most difficult are likely to be the contexts in which anemia is most prevalent. All of the hemoglobin concentrations in this chapter have been adjusted for altitude and smoking as appropriate.

4.1. Variations in the mean, median, and standard deviation

We now describe the central tendency and dispersion of hemoglobin concentrations in the surveys. Highly dispersed measurements can result either from a genuinely high level of dispersion in the population or from the addition of errors to the correct values. Errors of measurement are easiest to detect in the tails, although such errors can occur anywhere within the distribution. If the errors of measurement are random, and approximately equally likely to be upward or downward, then *both* tails will be spuriously extended. If, for example, the left tail of the distribution is extended and the right tail is not, and it is believed that measurement error is responsible, then a mechanism for displacement that is disproportionately downward may be indicated. It is important not to jump to a conclusion that unusually high or low dispersions are incorrect, because populations may indeed include severely anemic subpopulations, or may be uniformly healthy.

The averages of the mean, median, standard deviation across surveys are shown in Table 4.1.1 and Table 4.1.2, with implausible values included and excluded, respectively. In addition, the percentage of surveys with standard deviation below 1.1 or above 1.5 are presented. Figures 4.1.1, 4.1.2, and 4.1.3 present the distribution of the standard deviation of the hemoglobin concentration (excluding implausible values) for children, women, and men. There are almost no surveys with a standard deviation below 1.1, but a large percentage of surveys are above 1.5 even when implausible values are excluded. Standard deviations above 1.5 are most common for surveys of men.

Table 4.1.1 Summary statistics for hemoglobin concentrations across surveys, not excluding implausible values

	Mean of Mean	Mean of Median	Mean of SD	Surveys with hb SD<1.1 (%)	Surveys with hb SD>1.5 (%)
Population					
Children	10.58	10.67	1.79	0.0%	58.8%
Women (age 15-49)	12.34	12.46	1.85	0.0%	81.5%
Men (age 15 and above)	14.23	14.32	2.01	0.0%	96.3%

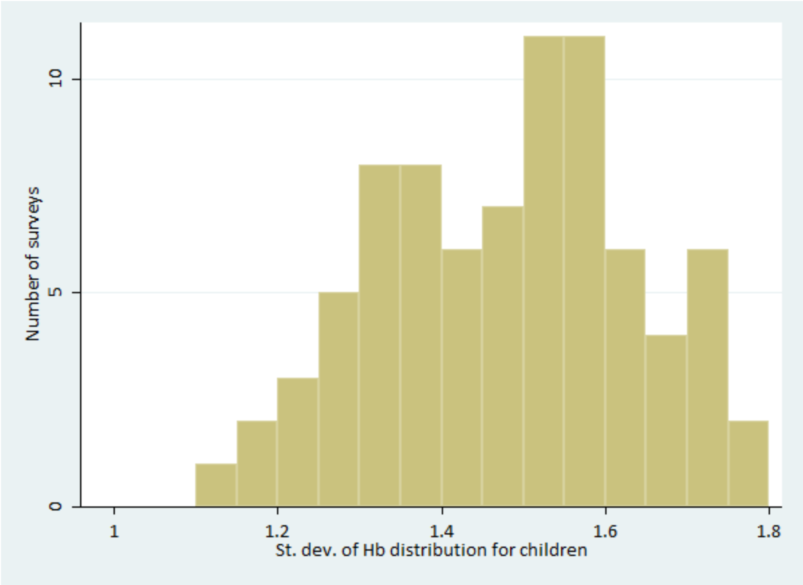
Note: Hb, hemoglobin; Adjusted for smoking and altitude when applicable

Table 4.1.2 Summary statistics for hemoglobin concentrations across surveys, excluding implausible values

	Mean of Mean	Mean of Median	Mean of SD	Surveys with hb SD<1.1 (%)	Surveys with hb SD>1.5 (%)
Population					
Children	10.57	10.67	1.48	0.0%	46.3%
Women (age 15-49)	12.33	12.46	1.58	0.0%	70.8%
Men (age 15 and above)	14.21	14.32	1.79	0.0%	96.3%

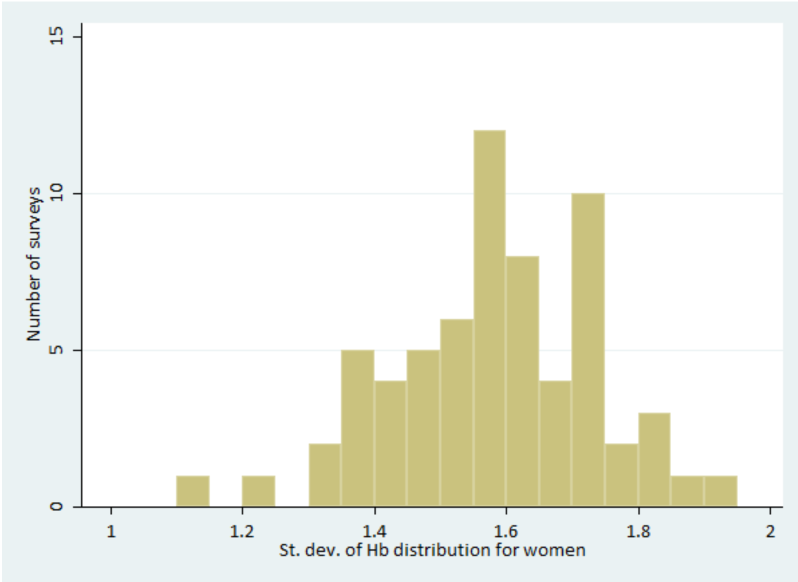
Note: Hb, hemoglobin; Implausible values defined as hemoglobin values outside of 4 g/dL to 18 g/dL for children and nonpregnant women and 4 g/dL to 20 g/dL for men after adjusting for altitude and smoking when applicable.

Figure 4.1.1 Distribution of the standard deviation of the hemoglobin concentration for children, excluding implausible values.



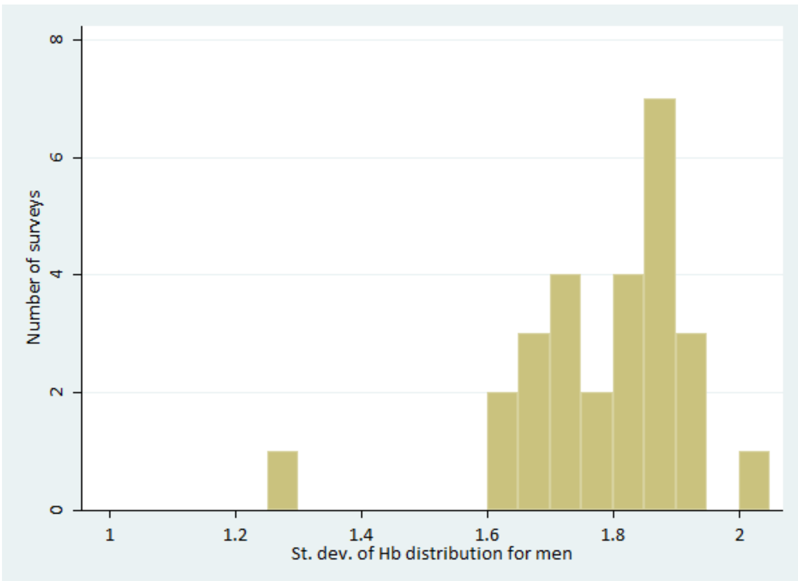
Note: Implausible values defined as hemoglobin values outside of 4 g/dL to 18 g/dL after adjustments to altitude when applicable

Figure 4.1.2 Distribution of the standard deviation of the hemoglobin concentration for women, excluding implausible values.



Note: Implausible values defined as hemoglobin values outside of 4 g/dL to 18 g/dL after adjustments to smoking and altitude when applicable

Figure 4.1.3 Distribution of the standard deviation of the hemoglobin concentration for men, excluding implausible values.



Note: Implausible values defined as hemoglobin values outside of 4 g/dL to 20 g/dL after adjustments to smoking and altitude when applicable

Figure 4.1.4 shows the distribution of hemoglobin concentrations for the 8 surveys of children with the greatest dispersion: Guinea 2012 (1.72), Niger 2006 (1.73), Cameroon 2004 (1.73), Ethiopia 2016 (1.73), Mali 2012-13 (1.74), Burkina Faso 2014 (1.74), Ethiopia 2011 (1.77), and Yemen 2013 (1.79). In all of these surveys the standard deviation is greater than 1.7 (but less than 1.8). Figure 4.1.5 shows the distribution of hemoglobin for children for two of the surveys that are most concentrated: Albania 2008-09 (1.15) and Egypt 2014 (1.17).

Figure 4.1.4 The distributions of hemoglobin concentrations in the surveys of children with highest dispersion

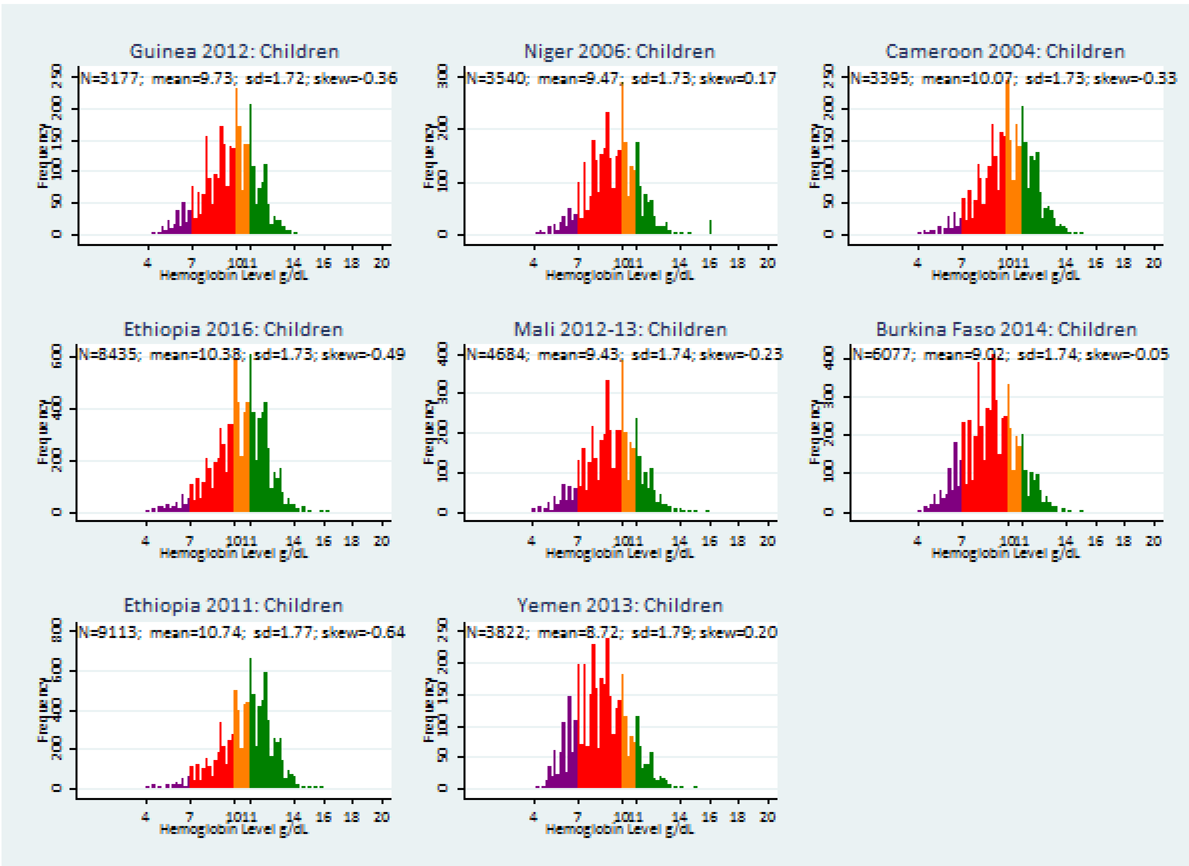
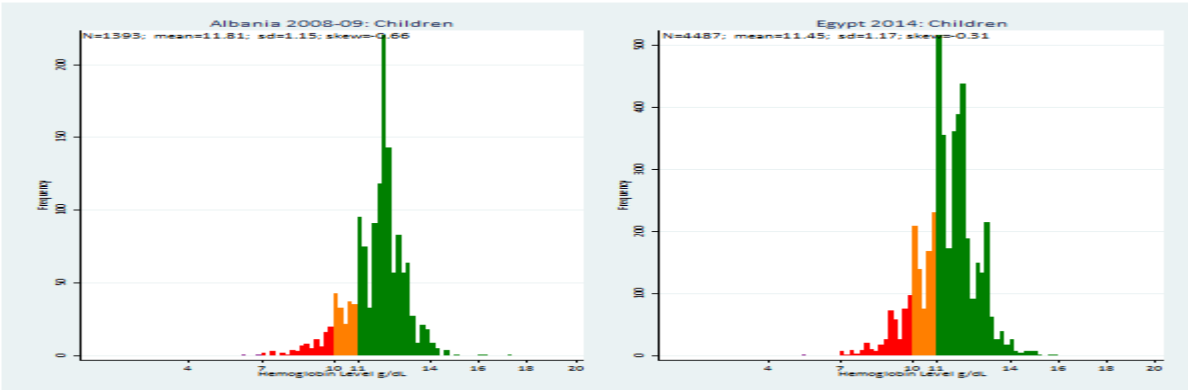


Figure 4.1.5 The distributions of hemoglobin concentrations in the surveys of children with lowest dispersion



The distributions for women tend to be more dispersed than the distributions for children (after excluding implausible values). The surveys with the largest standard deviations are Lesotho 2014 (1.80), Zimbabwe 2010-11 (1.83), Haiti 2005-06 (1.83), Niger 2006 (1.87), and Yemen 2013 (1.91). The surveys with the lowest standard deviations are Egypt 2014 (1.12) and Albania 2008-09 (1.21). Among men, the surveys with the highest standard deviations are Benin 2006 (1.91), Ethiopia 2016 (1.91), Niger 2006 (1.94), and Congo Democratic Republic 2007 (2.02). Albania 2008-09 has the least dispersion (1.29).

For the 28 countries that had two surveys with hemoglobin measurements of children, Table 4.1.3 compares the standard deviations of the two surveys. The average absolute value of the difference is only 0.08. For 17 surveys, the second survey had a larger standard deviation. For 10 surveys, there was a decrease. For one survey there was no change.

Table 4.1.3 Standard deviations of hemoglobin measurements for 28 countries with two surveys that measured children age 6-59 months, adjusted for altitude and excluding values outside the range 4-18 g/dL

Survey 1		Survey 2	SD	Difference
Angola 2011	1.42	Angola 2015-16	1.42	0
Benin 2006	1.69	Benin 2011-12	1.56	-0.13
Bolivia 2003	1.56	Bolivia 2008	1.60	0.04
Burkina Faso 2010	1.66	Burkina Faso 2014	1.74	0.08
Burundi 2010	1.36	Burundi 2012	1.56	0.2
Cambodia 2010	1.33	Cambodia 2014	1.28	-0.05
Cameroon 2004	1.73	Cameroon 2011	1.52	-0.21
Congo 2005	1.48	Congo 2011-12	1.33	-0.15
Congo DR 2007	1.68	Congo DR 2013-14	1.70	0.02
Ethiopia 2011	1.77	Ethiopia 2016	1.73	-0.04
Ghana 2014	1.55	Ghana 2016	1.49	-0.06
Guinea 2005	1.64	Guinea 2012	1.72	0.08
Haiti 2005-06	1.56	Haiti 2012	1.32	-0.24
Honduras 2005-06	1.30	Honduras 2011-12	1.24	-0.06
Jordan 2009	1.37	Jordan 2012	1.38	0.01
Lesotho 2009	1.48	Lesotho 2014	1.61	0.13
Madagascar 2013	1.47	Madagascar 2016	1.41	-0.06
Malawi 2014	1.50	Malawi 2015-16	1.47	-0.03
Mali 2012-13	1.74	Mali 2015	1.64	-0.1
Nepal 2006	1.37	Nepal 2011	1.35	-0.02
Niger 2006	1.73	Niger 2012	1.50	-0.23
Peru 2011	1.30	Peru 2012	1.26	-0.04
Rwanda 2010	1.35	Rwanda 2014-15	1.39	0.04

Senegal 2014	1.58	Senegal 2015	1.51	-0.07
Sierra Leone 2008	1.52	Sierra Leone 2013	1.61	0.09
Tanzania 2010	1.43	Tanzania 2015-16	1.47	0.04
Uganda 2011	1.62	Uganda 2014-15	1.60	-0.02
Zimbabwe 2010-11	1.43	Zimbabwe 2015	1.33	-0.1

Note: Congo DR, Congo Democratic Republic; SD, Standard deviation; Hemoglobin adjusted for altitude and smoking prior to removing implausible values

To summarize, at the national level, children tend to have more concentrated distributions than women, and women tend to have more concentrated distributions than men. Surveys that have higher dispersion may be less accurately measured. Nevertheless, it is also possible that wider distributions arise from genuinely high levels of heterogeneity in the true hemoglobin levels. There is relative stability of dispersion in successive surveys in the same country. It is difficult to make inferences about data quality based on unusually *low* levels of dispersion but there are no surveys that fall below our threshold of 1.1.

4.2. Association between the mean and standard deviation of the hemoglobin measurement

We have investigated possible reasons for why so many surveys have more dispersion than expected. One conspicuous pattern is a strong negative association between the mean and the standard deviation. For the hemoglobin measurements for children, as just described, the correlation between the mean and the standard deviation is -0.68.

Figure 4.2.1 Standard deviation plotted against the mean, for 80 surveys with hemoglobin measurements of children age 6-59 months, adjusted for altitude and excluding values outside the range 4-18 g/dL. Horizontal lines enclose the expected range of standard deviations, from 1.1 to 1.5

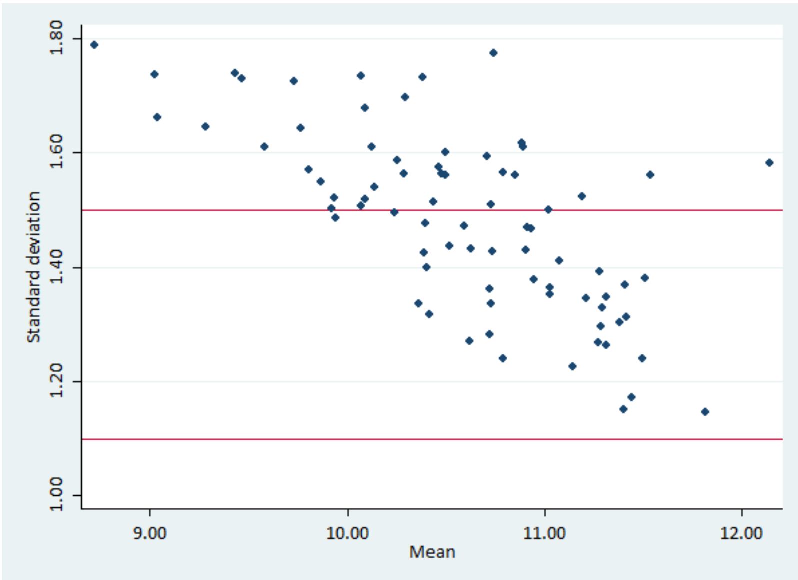
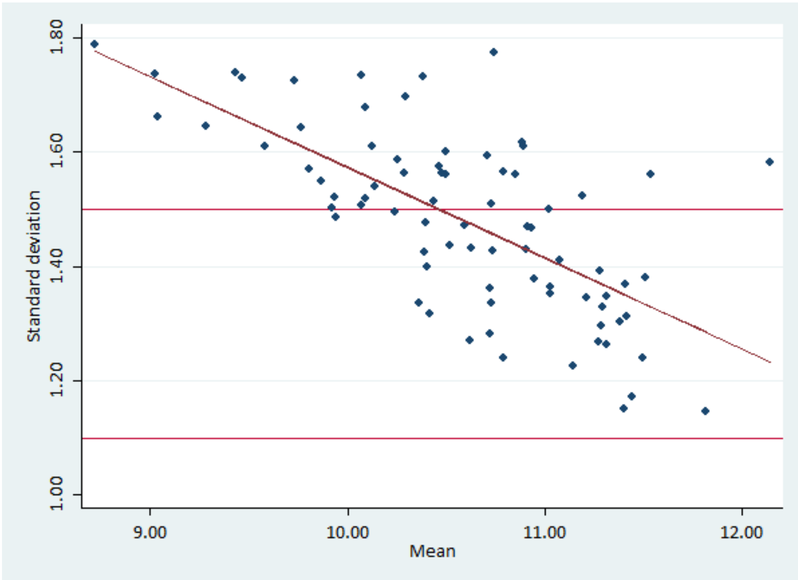


Figure 4.2.1 shows a scatterplot for the 80 surveys, with the mean on the horizontal axis and the standard deviation on the vertical axis. The 38 surveys with a standard deviation greater than 1.5 (but never greater than 1.8) are indicated by points above the upper horizontal red line. There is a clear pattern, in which a higher standard deviation tends to correspond with a lower mean. Figure 4.2.2 is identical to Figure 4.2.1, but with the addition of a regression line.

Surveys with low means, especially below 10 or so, indicate that the prevalence of any anemia is very high. When a low mean is accompanied by a high standard deviation, the prevalence of severe anemia is usually even greater than it would be with a smaller standard deviation, because there will be more cases in the tails of the distribution. Conversely, a high mean corresponds with a low prevalence of any anemia. Because a high mean tends to be accompanied by a low standard deviation, the left tail tends to be particularly short and the prevalence of severe anemia tends to be particularly low.

Figure 4.2.2 Standard deviation plotted against the mean, for 80 surveys with hemoglobin measurements of children age 6-59 months, adjusted for altitude and excluding values outside the range 4-18 g/dL. Horizontal lines enclose the expected range of standard deviations, from 1.1 to 1.5. The diagonal is the fitted line from a regression of the standard deviation on the mean (y=3.16-0.16x)



It is possible that this strong negative association between the mean and the standard deviation of the distribution is a byproduct of measurement error, but it may also suggest a real association among the prevalences of mild, moderate, and severe anemia, regardless of the specific cutoffs assigned to those categories. The suggested implication is that if the prevalence of any anemia is high, the prevalence of severe anemia will be especially high; if the prevalence of any anemia is low, the prevalence of severe anemia will be especially low.

4.3. Variation in shape

Next, we consider the shape of the distribution of hemoglobin measurements, and more specifically, skew and kurtosis. The coefficient that measures skew is 0 for a symmetric distribution, negative if extreme values tend to be on the left, and positive if extreme values tend to be on the right. The mean skew is presented in Tables 4.31 and 4.3.2, not excluding and excluding implausible values, respectively. The positive skew in Table 4.3.1 is due to a small number of out-of-range codes with high numeric values. After excluding the out-of-range values, Table 4.3.2 shows that the hemoglobin distributions tend to be skewed slightly to the left, with the greatest skew among women and the lowest skew among children.

Table 4.3.1 Summary statistics for skew of hemoglobin concentrations across surveys, not excluding implausible values

	Mean of Skew	Surveys with skew <- 0.5 (%)	Surveys with skew >0.5 (%)
Population			
Children	3.01	33.8%	23.8%
Women (age 15-49)	2.46	63.1%	27.7%
Men (age 15 and above)	1.95	48.1%	22.2%

Note: Adjusted for smoking and altitude when applicable

Table 4.3.2 Summary statistics for skew of hemoglobin concentrations across surveys, excluding implausible values

	Mean of Skew	Surveys with skew <-0.5 (%)	Surveys with skew >0.5 (%)
Population			
Children	-0.39	20.0%	0.0%
Women (age 15-49)	-0.61	75.4%	0.0%
Men (age 15 and above)	-0.51	44.4%	0.0%

Note: Implausible values defined as hemoglobin values outside of 4 g/dL to 18 g/dL for children and nonpregnant women and 4 g/dL to 20 g/dL for men after adjusting for altitude and smoking when applicable

Figure 4.3.1 is a histogram that shows the distribution of the skew across the hemoglobin distributions for children excluding implausible values. Although the distributions are much more often skewed to the left, rather than the right, the magnitude of the skew is relatively small. Seventeen surveys have a coefficient below -0.5. No surveys have a coefficient greater than 0.5.

The greatest skew is found in the following 7 surveys: Burundi 2012 (-0.75), Armenia 2005 (-0.72), Kyrgyz Republic 2012 (-0.70), Albania 2008-09 (-0.66), Rwanda 2014-15 (-0.64), and Peru 2011 (-0.60). The distributions of hemoglobin for children in these surveys are shown in Figure 4.3.2. Visually, the distributions appear close to normal, although a slightly exaggerated tail extending to the left is visible. The far left of each distribution includes a few cases with hemoglobin levels below 7 (colored purple), the cutoff for extreme anemia.

Figure 4.3.1 Histogram of the skew of the hemoglobin distribution for children in the 80 surveys that included hemoglobin measurements for children

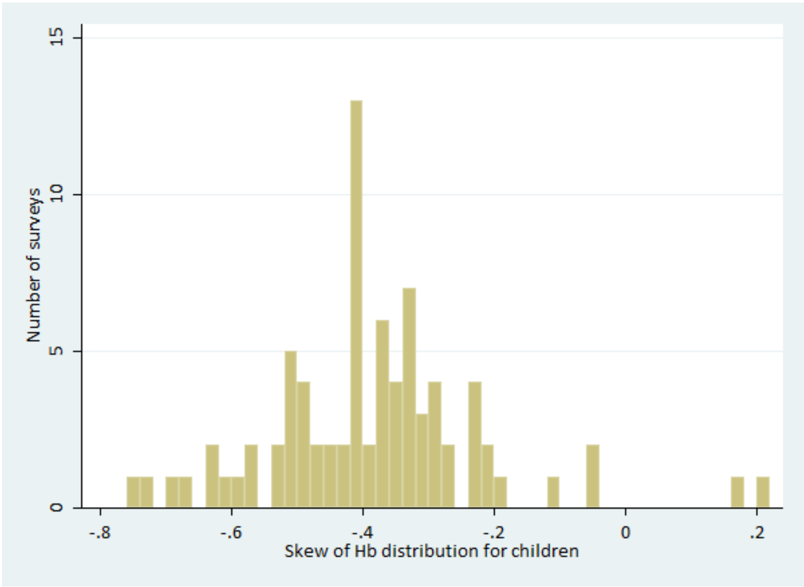
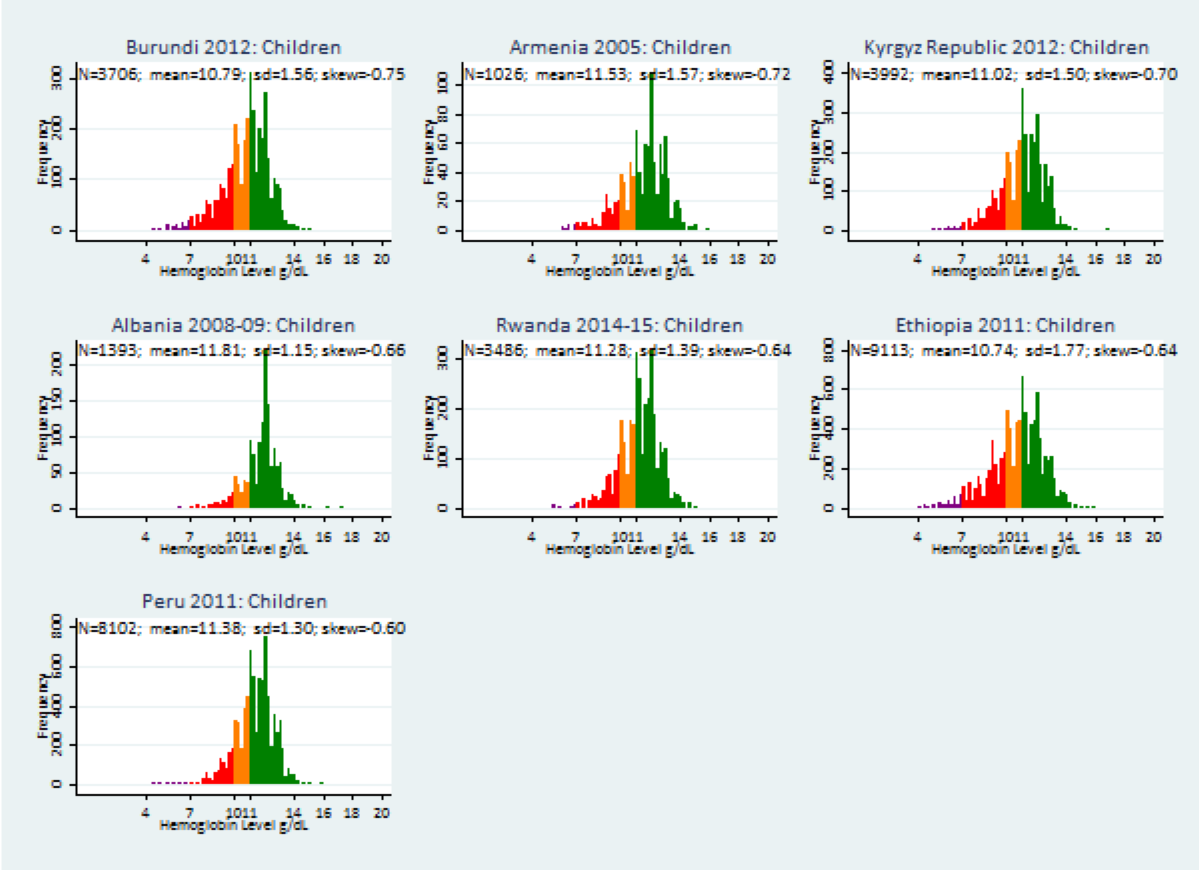


Figure 4.3.2 The distributions of hemoglobin for children in the surveys with skew <-0.5



The skew for the hemoglobin distributions for women ranges from -0.99 to -0.12. No distributions are even mildly skewed to the right, and many more distributions are noticeably skewed to the left. A total of 50 surveys deviate from the normal standard by more than 0.5 units. These surveys represent 83% of the surveys of women, whereas only 20% of the surveys of children showed that amount of skew. The distribution of the skew is shown in Figure 4.3.3.

Rather than list all 50 surveys with a skew below -0.5, we list and show the 7 with a value below -0.8: Ethiopia 2011 (-0.99), Azerbaijan 2006 (-0.95), Armenia 2005 (-0.95), Kyrgyz Republic 2012 (-0.95), Peru 2011 (-0.89), Ethiopia 2016 (-0.88), and Uganda 2011 (-0.81).The distributions for these seven surveys with greatest (negative) skew are shown in Figure 4.3.4. The extended tails on the left are indeed more conspicuous, and include most cases of severe and moderate anemia.

Figure 4.3.3 Histogram of the skew of the hemoglobin distribution for women in the 65 surveys that included hemoglobin measurements for women

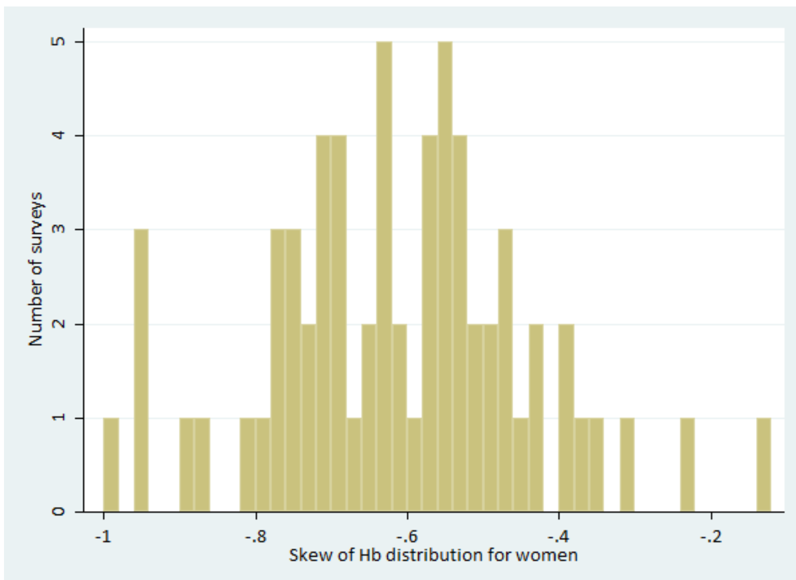
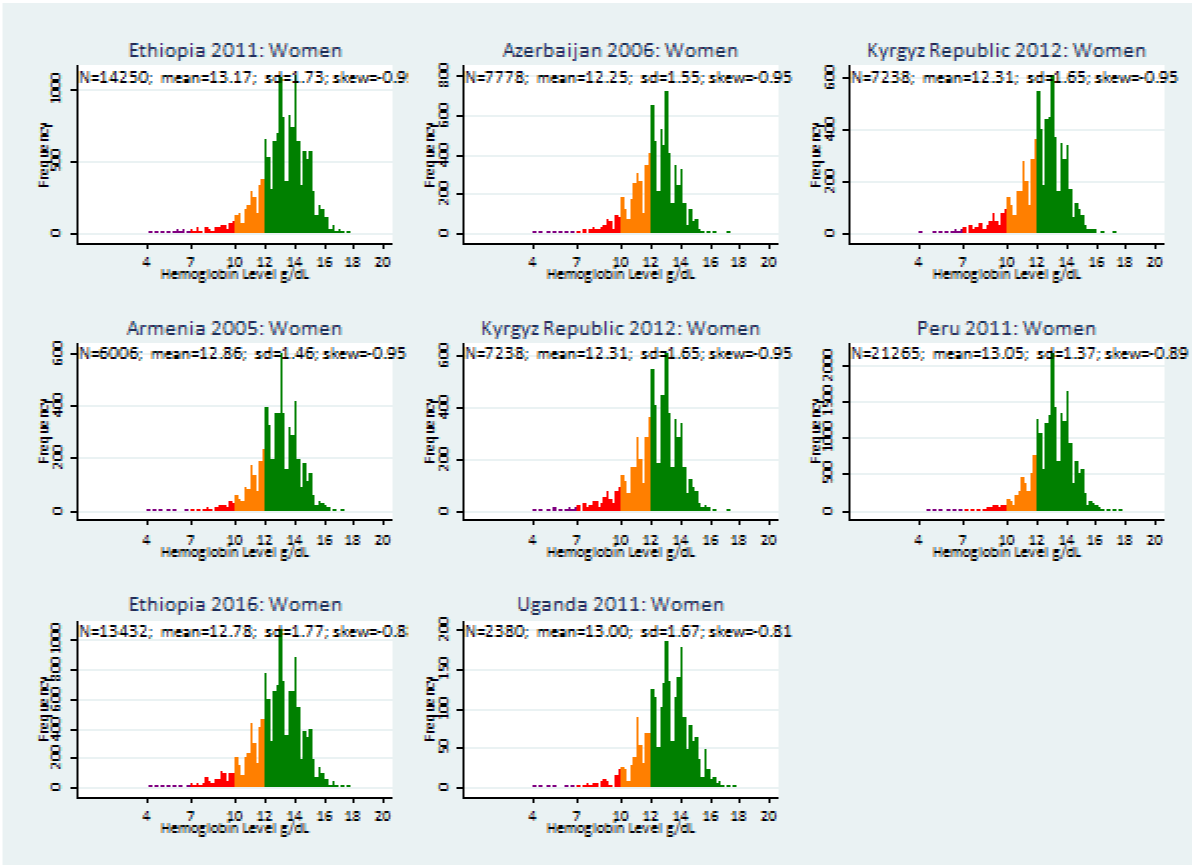


Figure 4.3.4 The distributions of hemoglobin for women in the surveys with skew <-0.7



The second indicator of departure from the shape of a normal distribution is the kurtosis. The coefficient for kurtosis is 3 for a normal distribution. It is greater than 3 if the distribution tends to have longer tails than a normal distribution (with the same mean and standard deviation), and less than 3 if the distribution has shorter tails than a normal distribution. One marker is a deviation of one unit below or above the reference value of 3.

The mean kurtosis is presented in Tables 4.3.3 and 4.3.4, including and excluding implausible values, respectively. As with the skew, the inclusion of out-of-range or implausible values leads to very high but misleading coefficients. When those values or excluded, the kurtosis is still almost always greater than 3, but is typically in the vicinity of 4—usually less than 4 for children but usually more than 4 for women and men.

The distribution of kurtosis across the 80 surveys is shown in Figure 4.3.5. The distributions for children have a kurtosis in the range of 2.59 to 5.09. Several distributions are slightly more concentrated than the standard of 3, although there are no distributions more than one unit below 3, i.e. below 2. The following 5 surveys have a kurtosis that is more than one unit above 3, i.e. more than 4.0: Albania 2008-09 (5.09), Rwanda 2010 (4.94), Rwanda 2014-15 (4.26), Honduras 2005-06 (4.17), and Niger 2006 (4.07).

These 5 distributions are shown in Figure 4.3.6. The figures do not include the value of the kurtosis, but it is listed above. There is visual evidence of extreme observations in both directions. Three of these surveys with relatively high kurtosis also had relatively high skew to the left—that is, the tails are long on both directions but especially on the left: Albania 2008-09; Rwanda 2014-15; and Honduras 2005-06. Most of these distributions do not show unusually high levels of anemia.

Table 4.3.3. Summary statistics for kurtosis of hemoglobin concentrations across surveys, not excluding implausible values

	Mean of kurtosis	Surveys with kurtosis <2 (%)	Surveys with kurtosis >4 (%)
Population			
Children	112.33	0.0%	62.5%
Women (age 15-49)	103.56	0.0%	93.8%
Men (age 15 and above)	80.95	0.0%	88.9%

Note: Adjusted for smoking and altitude when applicable

Table 4.3.4. Summary statistics for kurtosis of hemoglobin concentrations across surveys, excluding implausible values

	Mean of kurtosis	Surveys with kurtosis <2 (%)	Surveys with kurtosis >4 (%)
Population			
Children	3.54	0.0%	6.3%
Women (age 15-49)	4.25	0.0%	61.5%
Men (age 15 and above)	4.16	0.0%	55.6%

Note: Implausible values defined as hemoglobin values outside of 4 g/dL to 18 g/dL for children and nonpregnant women and 4 g/dL to 20 g/dL for men after adjusting for altitude and smoking when applicable

Figure 4.3.5 Histogram of the kurtosis of the hemoglobin distribution for children in the 80 surveys that included hemoglobin measurements for children

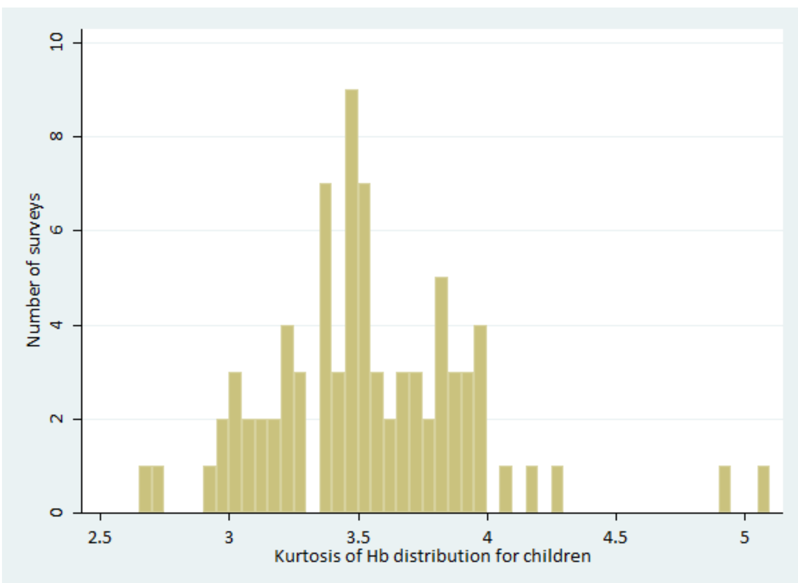
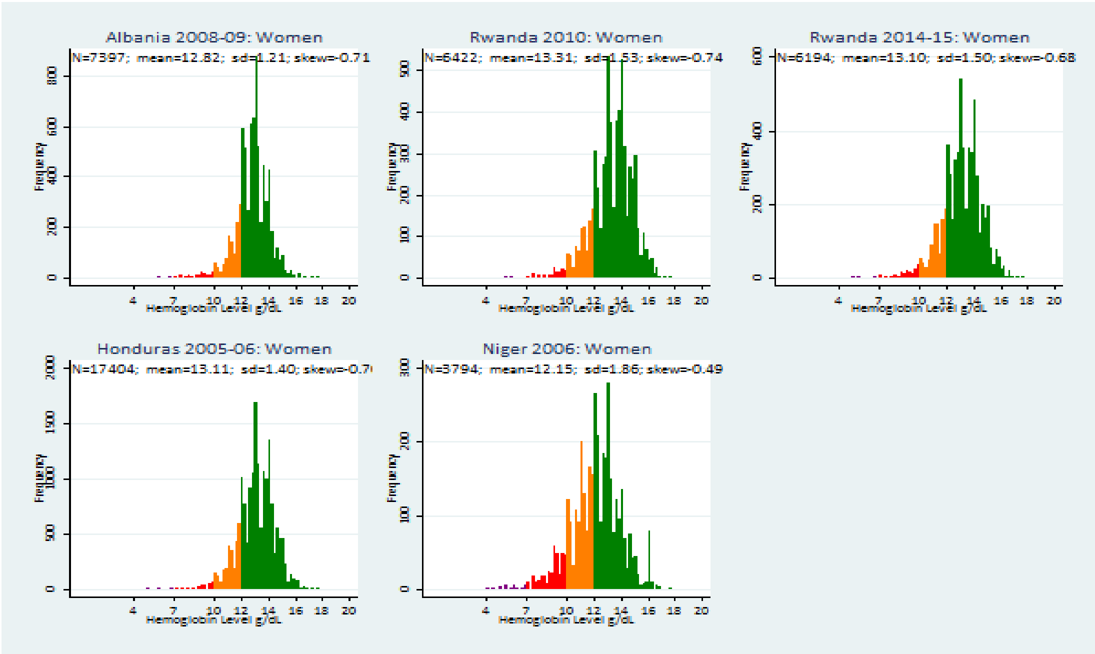


Figure 4.3.6 The distributions of hemoglobin for children in the surveys with kurtosis >4

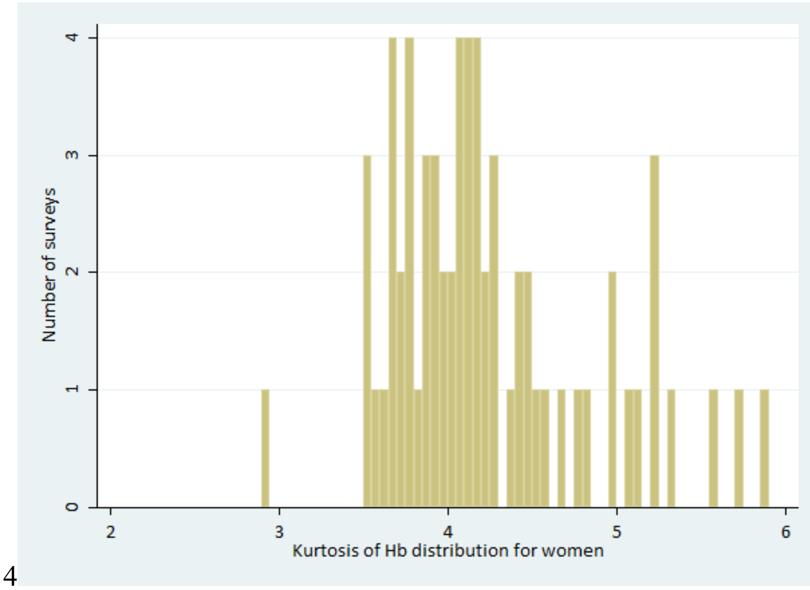


Next we apply the same standards to the distributions for women, which show some conspicuous differences from children. The distribution of kurtosis across the 65 surveys that included measurements of women is shown in Figure 4.3.7. The kurtosis of the hemoglobin distributions for women is shifted in the direction of even more cases in the tails than was observed in the distributions for children, with a range from 2.91 to 5.89. The lowest values match almost exactly with the standard of a normal distribution. A total of 40 surveys—62% of the surveys of women—have a kurtosis that exceeds 4, compared with 6% of the surveys of children.

Rather than list all 40 surveys, we set a higher threshold and list the 9 surveys with kurtosis greater than 5: Armenia 2005 (5.89), Albania 2008-09 (5.72), Peru 2011 (5.59), Timor-Leste 2009-10 (5.31), Azerbaijan 2006 (5.24), Ethiopia 2011 (5.23), Peru 2012 (5.22), Egypt 2014 (5.14), and Guatemala 2014-15 (5.08). The distributions for these surveys are shown in Figure 4.3.8.

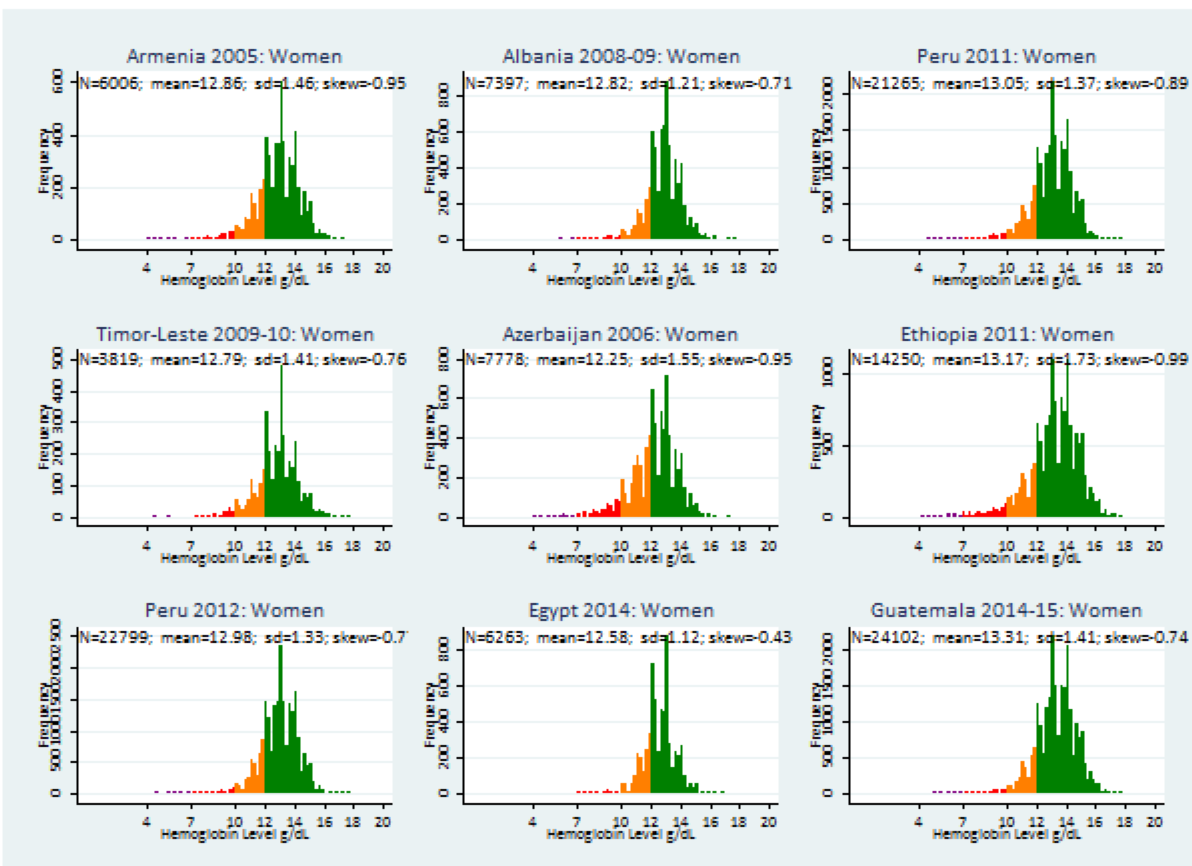
Surveys with high kurtosis tend to have high levels of skew. Four surveys—Armenia 2005, Albania 2008-09, Peru 2011, and Ethiopia 2011—appeared on both the lists of the greatest skew and the greatest kurtosis.

Figure 4.3.7 Histogram of the kurtosis of the hemoglobin distribution for women in the 65 surveys that included hemoglobin measurements for women



4

Figure 4.3.8 The distributions of hemoglobin for women in the surveys with kurtosis >5



Because of the way they are formally defined, skew and kurtosis are necessarily associated with each other and with the standard deviation Among the 80 distributions of hemoglobin for children, the correlation between abs(skew) and kurtosis is 0.38. Among the 65 distributions for women, the same correlation is 0.70. One should therefore be cautious about over-interpreting the overlap between the surveys identified by large standard deviations, skew, and kurtosis.

4.4. Variations in the mean, median, and standard deviation by covariates for children and women

Table 4.4.1 and Table 4.4.2 present the mean values of the mean, median, and standard deviation stratified by covariates for children and women, respectively. In addition, information is provided in these tables on the percentage of surveys that are below 1.1 standard deviations and above 1.5 standard deviations. On average, the mean, median, and standard deviation of hemoglobin concentrations increase slightly as wealth increases from the bottom quintile to the top quintile. Stratifying children by age showed slight increases in the mean and median hemoglobin concentrations with increasing age. The lowest level of dispersion was for children age 6 to 11 months. For girls, compared with boys, the mean and median tend to be slightly higher and the dispersion is lower. Overall, the mean and median are higher in urban areas, compared to rural areas; dispersion is higher in rural areas. A similar pattern is seen for urban and rural residence and wealth quintiles in women. Hemoglobin concentrations slightly decrease and the dispersion increases on average as age increases in women. As respondent’s education increases, the mean and median hemoglobin concentrations increase and the dispersion decreases in women.

Table 4.4.1. Average of the mean, median, standard deviation skew, and kurtosis of hemoglobin concentrations for children excluding implausible values, by covariates

	Mean of Mean	Mean of Median	Mean of SD	Surveys with Hb SD<1.1 (%)	Surveys with Hb SD>1.5 (%)
Residence					
Urban	10.72	10.83	1.44	1.3%	32.5%
Rural	10.50	10.60	1.49	0.0%	50.0%
Wealth					
Quintile 1	10.39	10.48	1.50	0.0%	53.8%
Quintile 2	10.47	10.59	1.48	0.0%	50.0%
Quintile 3	10.56	10.66	1.47	0.0%	40.0%
Quintile 4	10.68	10.77	1.44	1.3%	36.3%
Quintile 5	10.91	11.01	1.39	3.8%	27.5%
Age (months)					
6-11	9.98	10.06	1.42	1.3%	28.8%
12-23	10.09	10.19	1.46	0.0%	38.8%
24-59	10.82	10.92	1.42	3.8%	36.3%
Sex					
Male	10.52	10.63	1.50	0.0%	53.8%
Female	10.61	10.72	1.46	1.3%	40.0%

Note: Implausible values defined as hemoglobin values outside of 4 g/dL to 18 g/dL after adjusting for altitude when applicable

Table 4.4.2. Average of the mean, median, standard deviation skew, and kurtosis of hemoglobin concentrations for women excluding implausible values, by covariates

	Mean of Mean	Mean of Median	Mean of SD	Surveys with Hb SD<1.1 (%)	Surveys with Hb SD>1.5 (%)
Residence					
Urban	12.36	12.50	1.57	1.5%	67.7%
Rural	12.31	12.44	1.59	0.0%	72.3%
Wealth					
Quintile 1	12.25	12.38	1.59	0.0%	73.8%
Quintile 2	12.29	12.42	1.59	0.0%	78.5%
Quintile 3	12.31	12.44	1.58	0.0%	72.3%
Quintile 4	12.35	12.47	1.57	1.5%	64.6%
Quintile 5	12.41	12.53	1.53	3.1%	60.0%
Age (year)					
15-19	12.34	12.46	1.51	1.5%	53.8%
20-34	12.35	12.48	1.56	1.5%	64.6%
35-49	12.29	12.45	1.64	0.0%	83.1%
Education					
No education	12.27	12.40	1.63	0.0%	78.1%
Primary	12.38	12.51	1.58	1.6%	70.3%
Secondary	12.41	12.52	1.54	0.0%	60.9%
Higher	12.46	12.59	1.51	6.3%	50.0%

Note: Implausible values defined as hemoglobin values outside of 4 g/dL to 18 g/dL after adjusting for altitude and smoking when applicable

5. Summary and Conclusions

This report has had two goals: to assess the quality of DHS measurements of hemoglobin concentrations, and to make inferences about how the underlying or true distributions of such concentrations may systematically vary across different populations. There has inevitably been some confounding of those two goals, but this chapter will summarize our conclusions. The report uses all the hemoglobin data collected by DHS since 2000, except that only the two most recent surveys were used from countries that had more than two surveys in this time interval. The analysis includes data from children age 6-59 months (80 surveys), nonpregnant women age 15-49 (65 surveys), and men age 15 and over (27 surveys; the upper end of the age range is usually 59 but varies somewhat). Measurements are generally comparable between DHS surveys and over time because standard collection and analysis procedures are used.

Despite the rigorous standards of training and supervision in DHS surveys, the inclusion of biomarker specialists on most teams of interviewers, and the use of high quality equipment, there is room for measurement error. Our approaches to assessing the quality of hemoglobin data included checking for potential bias when subsampling was used, examining the relative frequency of missing values and biologically implausible values, checking the measurements for potential digit preference, and identifying potential over-dispersion in the distributions. Similar methods have been applied elsewhere to assess data quality for anthropometric measurements (Assaf, Kothari, and Pullum 2015) and ages and dates (Pullum 2006). Overall, we find that in most surveys the hemoglobin data are of high quality.

In the surveys with subsampling, the selection of participants is generally applied consistently across geographic units and household characteristics. There are some statistically significant relationships between the selection for hemoglobin measurement and the education of the head of household, wealth quintile, and urban/rural residence, but the differences in observed sampling fractions, across subpopulations, were at most 2 to 3 percentage points even when statistically significant. Re-weighting to compensate for this kind of variation would have a negligible effect. Based on this information, we conclude that the national estimates from the surveys are not biased toward identifiable subpopulations.

A high occurrence of incomplete data results in a reduced effective sample size, wasted time and money, wider confidence intervals for estimates, and lower power for tests. In addition, values outside of the plausible range can result in an over or underestimation of anemia. Hemoglobin measurements were successfully obtained for the great majority of selected respondents. The codes to describe the reasons for missing observations are not uniformly applied across surveys. In particular, there are some surveys in which household members who were not available or who refused to be measured were apparently given a "not applicable" code. Such deviations from normal practice can result in users of DHS data potentially misinterpreting the data when conducting secondary analyses. Most instances of inconsistent codes were in older surveys.

When DHS converts the hemoglobin measurements to anemia levels in the main survey reports, there is no flagging or removal of values that are highly improbable and are almost certainly data entry errors. There are no international guidelines for removing such cases, and because there are not many of them, they have little net effect on the estimates of anemia. However, values outside of a plausible range can have a substantial effect on the statistics to describe the distribution, particularly the standard deviation, skew, and kurtosis. In this analysis we identified and then removed the values that were outside a plausible range.

Many summary statistics were presented twice, with and without the inclusion of those cases. The range selected is somewhat arbitrary, but has been used elsewhere (Sullivan et al. 2008). There is a need for a consensus about plausible ranges for children, women, and men. Until that consensus is reached, DHS could consider adopting the ranges defined in this report rather than assigning extremely low hemoglobin concentrations, such as "0.0 g/dL", into the category of "severe anemia" or assigning extremely high hemoglobin concentrations, such as "88.0 g/dL", into the "no anemia" category.

A check for digit preference showed evidence of heaping at final digits 0 and 2 and a deficits for digits 6-9, although these patterns are found in only a minority of surveys. The pattern and level of heaping has a negligible effect on the calculation of means and proportions, but in some surveys could result in a slight underestimation of anemia because of an apparent upward transfer from 6-9 into 0, and the lower boundaries for all of the anemia categories end in final digit 0. A greater concern is that digit preference is considered to be a symptom of carelessness and can suggest more serious measurement errors. In a few surveys, final digits 0 and 5 occur much less often than expected, almost certainly because of an over-reaction to special efforts to avoid those digits. Training of interviewers and supervisors that focuses on the symptoms of careless fieldwork, such as potential over-reporting of final digit 0, may not actually lead to better data.

We examined the distributions of hemoglobin measurements in terms of the mean, median, standard deviation, skew, and kurtosis. There is currently no established guideline for the standard deviation, but it has been suggested, based on empirical experience, that an acceptable range is between 1.1 and 1.5 g/dL (Sullivan et al. 2008). We found almost no national-level standard deviations below 1.1. A majority of the standard deviations were higher than this range, mostly between 1.5 and 2.0.

For skew and kurtosis, the shape parameters, the values for normal distribution (0 and 3, respectively) were taken as reference values. In the majority of surveys the data is skewed to the left, which we would generally assume to be the case in low- and middle-income countries, where anemia is common. The degree to which the skew and kurtosis of the distribution differ from those of a normal distribution, especially by large amounts, can indicate unevenness in the quality of the measurements, not just in the true distribution.

In a heterogeneous population, especially at the national level, or if there are serious inequalities in health, it is quite likely that the true distribution of hemoglobin is not normal. Therefore, we also looked at distributions stratified by residence, education, sex, wealth, and age. It was found that the standard deviation, skew, and kurtosis were greater for women than for children. We would have hypothesized more measurement error for children. It is more difficult to obtain a blood sample for a child, partly due to the small size of a child's finger. A possible explanation is that the prevalence of anemia is lower for adults than for children. We also found that the standard deviations tend to be smaller among the urban, wealthier, and more educated sub-populations but the standard deviations still remained high within sub-populations.

An important component of most data quality assessments is consistency with an external standard. Such comparisons have been conducted for anthropometry (Corsi, Perkins, and Subramanian 2017). External consistency is not included in this report because DHS is the principal source of hemoglobin measurements in the countries represented here. Future studies may be able to compare DHS data with other sources, such as national micronutrient surveys, albeit not in the same countries and time periods.

Many factors have the potential to influence the variability in hemoglobin concentrations other than improper and inadequate training of hemoglobin measurement and data management. Little is known about these factors although some studies have found a difference between capillary versus venous blood samples (Neufeld et al. 2002), use of different HemoCue® devices and/or models (Rappaport, Barr, Green, and Karakochuk 2017; Rappaport, Karakochuk, Whitfield, Kheang, and Green 2017), humidity (Nguyen 2002), inherent drop-to-drop variability (Bond and Richards-Kortum 2015; Conway, Hinchliffe, Earland, and Anderson 1998) and other biological variations (age, sex, anthropometry, clinical factors) (Karakochuk). The HEmoglobin MEasurement (HEME) Working Group is addressing some of these issues using secondary data, but more studies specifically designed to address these issues are needed. In addition, changes to the anemia cutoff values may have an even greater impact on the prevalence of anemia than measurement errors or inherent variations in hemoglobin concentrations. The current cutoffs recommended by WHO to define anemia are based on a 1968 report with limited data (World Health Organization 1968) and urgently need to be reviewed.

A better understanding of the factors that influence the accurate measurement and interpretation of hemoglobin concentrations would inform DHS data collection procedures and post-data collection adjustments to hemoglobin concentrations. Feasibility is central to the adoption of new approaches. For example, it has been proposed that pooling more than one drop of blood would provide greater within-subject reliability (Bond and Richards-Kortum 2015; Conway et al. 1998), although this will not be feasible in DHS surveys where several blood samples are needed to assess additional biomarkers. It may be feasible to apply further adjustments, such as those for altitude and smoking, if new factors are found to consistently alter hemoglobin concentrations.

Historically, anemia has been considered an indicator of iron deficiency. However, hemoglobin is neither a sensitive nor a specific biomarker for iron deficiency (Petry et al. 2016; World Health Organization and Centers for Disease Control and Prevention 2007). As a result, there is an increasing recognition that collecting micronutrient biomarkers, especially iron, and biomarkers of infections will better inform programming. Nevertheless, anemia is one of the seven World Health Assembly target indicators being tracked globally and remains an important indicator of overall well-being, analogous to stunting. Low and middle-income countries' primary source of anemia data comes from surveys conducted by The DHS Program. This report is an important step forward in better understanding the quality of data used to assess anemia and inform country and global policies.

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Appendix 1

Table A1.1 List of surveys for children, nonpregnant women, and men

Survey	Children	Women	Men
Albania 2008-09	X	X	X
Angola 2011	X	NA	NA
Angola 2015-16	X	NA	NA
Armenia 2005	X	X	NA
Azerbaijan 2006	X	X	NA
Bangladesh 2011	X	X	NA
Benin 2006	X	X	X
Benin 2011-12	X	X	NA
Bolivia 2003	X	X	NA
Bolivia 2008	X	X	NA
Burkina Faso 2010	X	X	X
Burkina Faso 2014	X	NA	NA
Burundi 2010	X	X	X
Burundi 2012	X	NA	NA
Cambodia 2010	X	X	NA
Cambodia 2014	X	X	NA
Cameroon 2004	X	X	NA
Cameroon 2011	X	X	NA
Congo 2005	X	X	NA
Congo 2011-12	X	X	NA
Congo Democratic Republic 2007	X	X	X
Congo Democratic Republic 2013-14	X	X	X
Cote d'Ivoire 2011-12	X	X	X
Egypt 2014	X	X	NA
Ethiopia 2011	X	X	X
Ethiopia 2016	X	X	X
Gabon 2012	X	X	X
Gambia 2013	X	X	NA
Ghana 2014	X	X	NA
Ghana 2016	X	NA	NA
Guatemala 2014-15	X	X	NA
Guinea 2005	X	X	NA
Guinea 2012	X	X	X
Guyana 2009	X	X	X
Haiti 2005-06	X	X	X
Haiti 2012	X	X	X
Honduras 2005-06	X	X	NA
Honduras 2011-12	X	X	NA
India 2005-06	X	X	X
Jordan 2009	X	X	NA
Jordan 2012	X	X	NA
Kenya 2015	X	NA	NA
Kyrgyz Republic 2012	X	X	NA
Lesotho 2009	X	X	X
Lesotho 2014	X	X	X
Liberia 2011	X	NA	NA
Madagascar 2013	X	NA	NA
Madagascar 2016	X	NA	NA
Malawi 2014	X	NA	NA
Malawi 2015-16	X	X	NA
Mali 2012-13	X	X	NA
Mali 2015	X	NA	NA
Moldova 2005	X	X	NA
Mozambique 2011	X	X	NA
Myanmar 2015-16	X	X	NA
Namibia 2013	X	X	X
Nepal 2006	X	X	NA
Nepal 2011	X	X	NA
Niger 2006	X	X	X
Niger 2012	X	X	X
Nigeria 2015	X	NA	NA
Peru 2011	X	X	NA
Peru 2012	X	X	NA

Rwanda 2010	X	X	NA
Rwanda 2014-15	X	X	NA
Sao Tome and Principe 2008-09	X	X	X
Senegal 2014	X	NA	NA
Senegal 2015	X	NA	NA
Sierra Leone 2008	X	X	X
Sierra Leone 2013	X	X	X
Swaziland 2006-07	X	X	X
Tanzania 2010	X	X	NA
Tanzania 2015-16	X	X	NA
Timor-Leste 2009-10	X	X	NA
Togo 2013-14	X	X	X
Uganda 2011	X	X	NA
Uganda 2014-15	X	NA	NA
Yemen 2013	X	X	NA
Zimbabwe 2010-11	X	X	X
Zimbabwe 2015	X	X	X
Total	80	65	27

Note: X = Survey measured, NA = Not measured

Appendix 2

Table A2.1 Summary of data completeness among children, by country

Country	Total Sample	Missing (%)	Final Sample	Hb<4 g/dL	Hb>18 g/dL	Implausible (%)	Valid (%)
Albania 2008-09	1,490	6.4%	1,394	0	1	0.1%	93%
Angola 2011	3,234	0.0%	3,234	1	0	0.0%	100%
Angola 2015-16	6,915	2.6%	6,734	44	4	0.7%	97%
Armenia 2005	1,267	18.8%	1,029	3	0	0.3%	81%
Azerbaijan 2006	1,963	8.1%	1,804	2	0	0.1%	92%
Bangladesh 2011	2,507	10.6%	2,242	1	0	0.0%	89%
Benin 2006	5,021	14.7%	4,282	9	2	0.3%	85%
Benin 2011-12	4,329	13.6%	3,739	15	0	0.4%	86%
Bolivia 2003	2,978	0.0%	2,978	2	0	0.1%	100%
Bolivia 2008	2,895	12.4%	2,535	6	1	0.3%	87%
Burkina Faso 2010	6,468	3.6%	6,234	13	0	0.2%	96%
Burkina Faso 2014	6,208	2.0%	6,083	6	0	0.1%	98%
Burundi 2010	3,473	6.6%	3,244	0	0	0.0%	93%
Burundi 2012	3,795	2.1%	3,715	8	1	0.2%	98%
Cambodia 2010	3,937	5.2%	3,734	1	0	0.0%	95%
Cambodia 2014	4,465	0.0%	4,465	0	0	0.0%	100%
Cameroon 2004	3,418	0.5%	3,401	5	1	0.2%	99%
Cameroon 2011	5,353	1.6%	5,268	5	3	0.2%	98%
Congo 2005	4,171	53.9%[1]	1,923	3	1	0.2%	46%
Congo 2011-12	4,436	4.9%	4,217	3	0	0.1%	95%
Congo DR 2007	3,952	10.7%	3,531	11	6	0.5%	89%
Congo DR 2013-14	8,395	2.6%	8,179	5	1	0.1%	97%
Cote d'Ivoire 2011-12	3,661	8.4%	3,353	3	1	0.1%	91%
Egypt 2014	4,568	1.8%	4,487	0	0	0.0%	98%
Ethiopia 2011	10,357	11.7%	9,142	26	3	0.3%	88%
Ethiopia 2016	9,010	6.2%	8,451	14	2	0.2%	94%
Gabon 2012	3,873	3.4%	3,741	2	3	0.1%	96%
Gambia 2013	3,889	15.5%	3,288	7	0	0.2%	84%
Ghana 2014	2,802	4.3%	2,681	1	0	0.0%	96%
Ghana 2016	3,063	1.5%	3,017	1	0	0.0%	98%
Guatemala 2014-15	11,265	4.1%	10,803	1	3	0.0%	96%
Guinea 2005	2,754	8.1%	2,530	3	5	0.3%	92%
Guinea 2012	3,256	2.2%	3,183	6	0	0.2%	98%
Guyana 2009	2,171	26.3%	1,601	2	0	0.1%	74%
Haiti 2005-06	2,701	1.6%	2,658	0	2	0.1%	98%
Haiti 2012	4,315	2.9%	4,190	1	0	0.0%	97%
Honduras 2005-06	9,119	0.1%	9,109	32	1	0.4%	100%
Honduras 2011-12	10,217	9.2%	9,279	4	27	0.3%	91%
India 2005-06	37,825	5.2%	35,870	14	6	0.1%	95%
Jordan 2009	4,274	12.4%	3,743	0	0	0.0%	88%
Jordan 2012	6,081	10.1%	5,468	4	1	0.1%	90%
Kenya 2015	3,635	6.6%	3,394	1	1	0.1%	93%
Kyrgyz Republic 2012	4,121	3.0%	3,998	3	3	0.2%	97%
Lesotho 2009	1,991	0.0%	1,991	2	1	0.2%	100%
Lesotho 2014	1,706	1.0%	1,689	2	1	0.2%	99%
Liberia 2011	3,267	3.2%	3,163	0	0	0.0%	97%
Madagascar 2013	5,558	3.3%	5,374	10	0	0.2%	97%
Madagascar 2016	7,199	2.4%	7,024	2	1	0.0%	98%
Malawi 2014	1,966	2.0%	1,927	1	0	0.1%	98%
Malawi 2015-16	5,363	2.4%	5,233	5	0	0.1%	97%
Mali 2012-13	5,044	6.9%	4,696	10	2	0.3%	93%
Mali 2015	7,297	1.0%	7,225	19	4	0.3%	99%
Moldova 2005	1,521	16.1%	1,276	0	12	0.9%	83%
Mozambique 2011	4,904	1.8%	4,815	4	1	0.1%	98%
Myanmar 2015-16	4,519	13.8%	3,896	1	0	0.0%	86%
Namibia 2013	2,388	4.3%	2,286	2	0	0.1%	96%
Nepal 2006	4,742	0.0%	4,742	0	1	0.0%	100%
Nepal 2011	2,227	5.0%	2,116	1	0	0.0%	95%
Niger 2006	4,048	12.4%	3,548	7	1	0.2%	87%
Niger 2012	5,602	14.1%	4,812	1	1	0.0%	86%
Nigeria 2015	6,274	4.9%	5,968	2	0	0.0%	95%
Peru 2011	8,488	4.5%	8,105	2	1	0.0%	95%

Peru 2012	9,029	4.5%	8,626	0	0	0.0%	96%
Rwanda 2010	4,068	1.1%	4,025	0	4	0.1%	99%
Rwanda 2014-15	3,501	0.4%	3,488	1	1	0.1%	100%
ST and Principe 2008-09	1,885	6.1%	1,770	5	0	0.3%	94%
Senegal 2014	6,274	3.7%	6,043	5	5	0.2%	96%
Senegal 2015	6,283	3.0%	6,097	2	0	0.0%	97%
Sierra Leone 2008	2,899	13.3%	2,512	6	2	0.3%	86%
Sierra Leone 2013	5,706	7.5%	5,280	5	2	0.1%	92%
Swaziland 2006-07	2,741	10.0%	2,466	0	0	0.0%	90%
Tanzania 2010	7,160	7.8%	6,603	7	0	0.1%	92%
Tanzania 2015-16	9,386	4.8%	8,931	7	0	0.1%	95%
Timor-Leste 2009-10	3,040	15.4%	2,572	17	0	0.7%	84%
Togo 2013-14	3,283	3.5%	3,169	1	0	0.0%	96%
Uganda 2011	2,337	9.2%	2,123	2	0	0.1%	91%
Uganda 2014-15	4,590	4.0%	4,407	2	0	0.0%	96%
Yemen 2013	4,669	18.0%	3,827	0	5	0.1%	82%
Zimbabwe 2010-11	5,292	19.7%	4,251	4	3	0.2%	80%
Zimbabwe 2015	5,857	12.3%	5,138	0	0	0.0%	88%

Note: Congo DR, Congo Democratic Republic; ST, Sao Tome; Total sample is defined de jure participant selected for hemoglobin measurement and is age 6-59 months; percentage of missing values is based on total sample; Final sample is defined as total sample minus hemoglobin measurement available; percentage of implausible values is based on final sample. Percentage of valid values is 100 minus the percentage of missing and implausible values.

[1] In the data file for the Congo 2005 survey, for children only, the missing value code "999" was assigned to children who were not measured because their household was not in the subsample selected for hemoglobin measurement. Such children should have received a "blank" code for "not applicable". This error was made during the construction of the public use data files and we could not correct it. If that error is taken into account, the correct level of missing was 11.2%, rather than 53.9%.

Table A2.2 Summary of data completeness among nonpregnant women, by country

	Total Sample	Missing (%)	Final Sample	Hb<4 g/dL	Hb>18 g/dL	Implausible (%)	Valid (%)
Albania 2008-09	7,422	0.4%	7,396	0	1	0.0%	100%
Armenia 2005	6,008	0.4%	5,986	6	3	0.2%	99%
Azerbaijan 2006	7,813	0.7%	7,760	4	2	0.1%	99%
Bangladesh 2011	5,295	2.7%	5,150	0	0	0.0%	97%
Benin 2006	4,523	0.8%	4,486	5	2	0.2%	99%
Benin 2011-12	5,447	14.7%	4,644	18	0	0.4%	85%
Bolivia 2003	5,608	0.0%	5,608	2	3	0.1%	100%
Bolivia 2008	5,486	0.0%	5,486	2	3	0.1%	100%
Burkina Faso 2010	7,916	4.1%	7,595	1	2	0.0%	96%
Burundi 2010	4,533	10.1%	4,074	0	2	0.0%	90%
Cambodia 2010	9,565	7.4%	8,860	8	5	0.1%	92%
Cambodia 2014	11,025	1.3%	10,880	0	0	0.0%	99%
Cameroon 2004	4,516	0.1%	4,513	4	0	0.1%	100%
Cameroon 2011	7,146	2.4%	6,974	2	1	0.0%	98%
Congo 2005	2,850	0.2%	2,843	3	1	0.1%	100%
Congo 2011-12	5,037	4.6%	4,806	0	1	0.0%	95%
Congo DR 2007	3,971	0.9%	3,934	13	17	0.8%	98%
Congo DR 2013-14	8,552	4.3%	8,182	3	6	0.1%	96%
Cote d'Ivoire 2011-12	5,130	14.7%	4,374	4	3	0.2%	85%
Egypt 2014	6,318	0.9%	6,263	0	0	0.0%	99%
Ethiopia 2011	16,237	12.1%	14,268	9	9	0.1%	88%
Ethiopia 2016	14,552	7.6%	13,440	3	5	0.1%	92%
Gabon 2012	5,012	3.0%	4,864	3	1	0.1%	97%
Gambia 2013	4,617	8.1%	4,243	4	2	0.1%	92%
Ghana 2014	4,668	7.1%	4,337	2	0	0.0%	93%
Guatemala 2014-15	24,876	3.1%	24,106	0	8	0.0%	97%
Guinea 2005	3,364	0.1%	3,361	5	1	0.2%	100%
Guinea 2012	4,300	3.4%	4,155	1	0	0.0%	97%
Guyana 2009	4,284	0.7%	4,254	1	3	0.1%	99%
Haiti 2005-06	4,781	0.0%	4,779	2	3	0.1%	100%
Haiti 2012	9,039	2.7%	8,792	9	1	0.1%	97%
Honduras 2005-06	17,458	0.0%	17,450	35	12	0.3%	100%
Honduras 2011-12	21,661	4.7%	20,648	0	79	0.4%	95%
India 2005-06	108,213	3.5%	104,474	68	20	0.1%	96%
Jordan 2009	7,378	7.7%	6,813	0	1	0.0%	92%
Jordan 2012	12,428	15.2%	10,538	0	5	0.0%	85%
Kyrgyz Republic 2012	7,481	3.2%	7,245	3	4	0.1%	97%
Lesotho 2009	3,605	0.0%	3,605	1	2	0.1%	100%
Lesotho 2014	3,151	1.3%	3,109	3	1	0.1%	99%
Malawi 2015-16	7,719	3.9%	7,421	5	3	0.1%	96%
Mali 2012-13	5,112	9.7%	4,618	4	0	0.1%	90%
Moldova 2005	6,778	0.4%	6,750	4	22	0.4%	99%
Mozambique 2011	12,446	2.4%	12,144	8	2	0.1%	97%
Myanmar 2015-16	12,164	0.7%	12,081	2	2	0.0%	99%
Namibia 2013	5,464	9.5%	4,944	1	4	0.1%	90%
Nepal 2006	9,835	0.0%	9,835	1	0	0.0%	100%
Nepal 2011	6,014	4.8%	5,724	1	1	0.0%	95%
Niger 2006	3,540	1.4%	3,489	3	3	0.2%	98%
Niger 2012	5,141	13.8%	4,432	2	1	0.1%	86%
Peru 2011	21,599	1.5%	21,279	12	2	0.1%	98%
Peru 2012	23,143	1.5%	22,807	2	6	0.0%	99%
Rwanda 2010	6,500	1.2%	6,425	2	1	0.0%	99%
Rwanda 2014-15	6,251	0.9%	6,197	0	3	0.0%	99%
ST and Principe 2008-09	2,356	1.1%	2,330	0	0	0.0%	99%
Sierra Leone 2008	3,102	2.8%	3,014	5	2	0.2%	97%
Sierra Leone 2013	7,688	5.1%	7,299	2	1	0.0%	95%
Swaziland 2006-07	4,761	10.2%	4,275	0	5	0.1%	90%
Tanzania 2010	9,806	10.2%	8,803	5	2	0.1%	90%
Tanzania 2015-16	12,514	7.1%	11,623	11	2	0.1%	93%
Timor-Leste 2009-10	4,216	9.3%	3,824	3	2	0.1%	91%
Togo 2013-14	4,433	2.2%	4,334	0	1	0.0%	98%
Uganda 2011	2,705	12.0%	2,381	1	0	0.0%	88%
Yemen 2013	4,315	0.8%	4,280	3	6	0.2%	99%
Zimbabwe 2010-11	9,005	17.5%	7,433	8	5	0.2%	82%
Zimbabwe 2015	9,228	6.7%	8,608	7	2	0.1%	93%

Note: Congo DR, Congo Democratic Republic; ST, Sao Tome; Total sample is defined de jure participant selected for hemoglobin measurement and is nonpregnant; percentage of missing values is based on total sample; Final sample is defined as total sample minus hemoglobin measurement available; percentage of implausible values is based on final sample. Percentage of valid values is 100 minus the percentage of missing and implausible values.

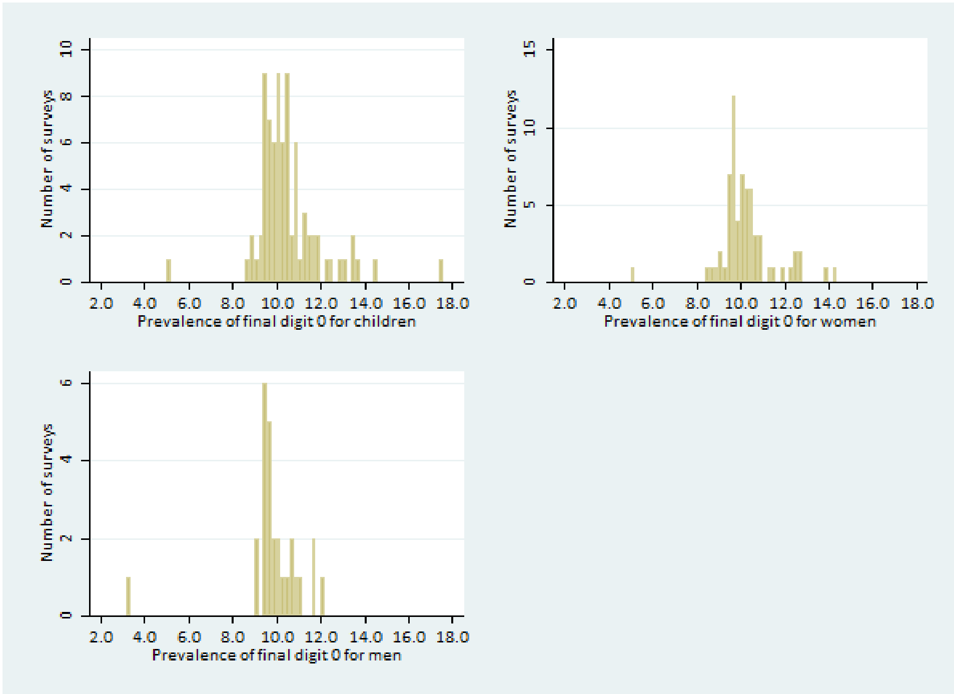
Table A2.3 Summary of data completeness among men, by country

	Total Sample	Missing (%)	Final Sample	Hb<4 g/dL	Hb>20 g/dL	Implausible (%)	Valid (%)
Albania 2008-09	3,193	6.4%	2,989	0	0	0.0%	94%
Benin 2006	6,043	26.6%	4,436	1	5	0.1%	73%
Burkina Faso 2010	7,677	6.5%	7,181	1	0	0.0%	94%
Burundi 2010	4,800	14.1%	4,125	1	1	0.0%	86%
Congo DR 2007	5,213	14.6%	4,453	4	20	0.5%	85%
Congo DR 2013-14	9,249	6.6%	8,643	2	8	0.1%	93%
Cote d'Ivoire 2011-12	5,607	20.0%	4,485	0	1	0.0%	80%
Ethiopia 2011	16,746	19.2%	13,525	8	17	0.2%	81%
Ethiopia 2016	15,517	24.1%	11,770	5	12	0.1%	76%
Gabon 2012	5,884	6.7%	5,488	0	2	0.0%	93%
Guinea 2012	3,850	4.4%	3,679	2	4	0.2%	95%
Guyana 2009	4,976	35.3%	3,217	0	2	0.1%	65%
Haiti 2005-06	5,100	5.0%	4,846	1	0	0.0%	95%
Haiti 2012	9,838	5.4%	9,305	2	1	0.0%	95%
India 2005-06	69,405	6.4%	64,933	20	29	0.1%	93%
Lesotho 2009	3,095	0.6%	3,077	0	5	0.2%	99%
Lesotho 2014	2,867	2.4%	2,799	3	1	0.1%	97%
Namibia 2013	4,942	16.3%	4,138	1	5	0.1%	84%
Niger 2006	4,068	23.1%	3,128	4	3	0.2%	77%
Niger 2012	4,975	28.3%	3,569	0	3	0.1%	72%
ST and Principe 2008-09	3,112	29.0%	2,210	0	0	0.0%	71%
Sierra Leone 2008	3,763	19.8%	3,019	3	3	0.2%	80%
Sierra Leone 2013	7,653	10.5%	6,853	0	1	0.0%	90%
Swaziland 2006-07	4,642	21.8%	3,628	0	3	0.1%	78%
Togo 2013-14	4,736	7.7%	4,373	1	4	0.1%	92%
Zimbabwe 2010-11	8,862	28.0%	6,379	1	11	0.2%	72%
Zimbabwe 2015	9,297	17.5%	7,669	2	1	0.0%	82%

Note: Congo DR, Congo Democratic Republic; ST, Sao Tome; Total sample is defined de jure participant selected for hemoglobin measurement; percentage of missing values is based on total sample; final sample is defined as total sample minus hemoglobin measurement available; percentage of implausible values is based on final sample. Percentage of valid values is 100 minus the percentage of missing and implausible values.

Appendix 3. Digit preferences

Figure A3.1 Distribution of the prevalence (percentage) of final digit 0 in the hemoglobin measurements for children age 6-59 months (80 surveys)[1], nonpregnant women age 15-49 (65 surveys)[2], and men (age range varies; 27 surveys)[2]. Expected value is 10%.

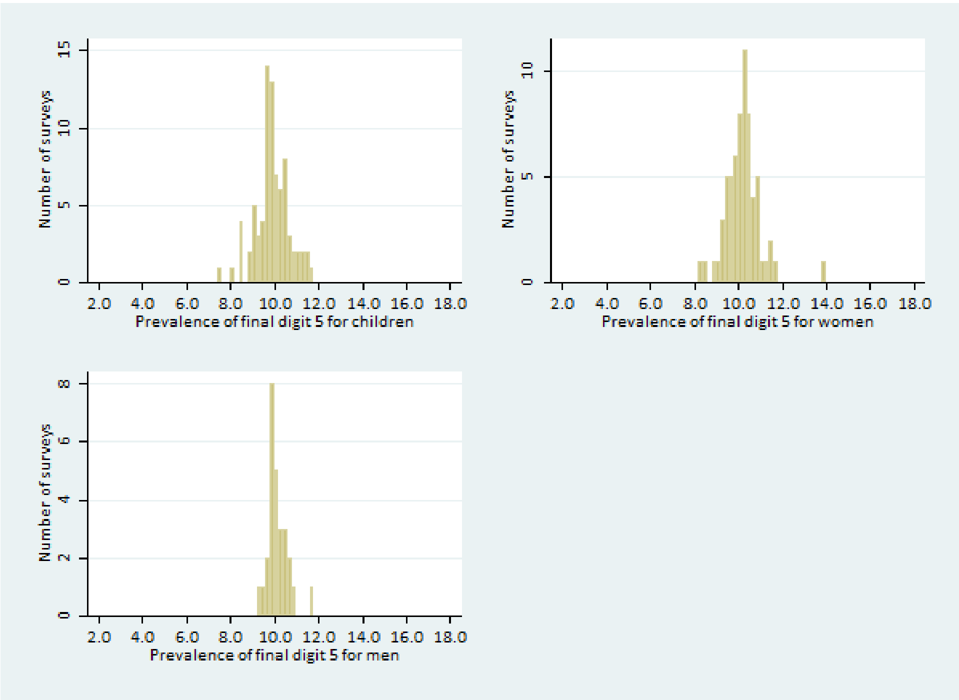


[1]Hemoglobin concentrations not adjusted for altitude
[2]Hemoglobin concentrations not adjusted for altitude and smoking

Table A3.1 Surveys and subpopulations for which the frequency of final digit 0, for the unadjusted hemoglobin concentration, has the greatest deviation from 10%

Frequency of digit 0 is less than 8%:		
Albania 2008-09	Men	3.3
Albania 2008-09	Women	5.1
Albania 2008-09	Children	5.2
Frequency of digit 0 is more than 12%:		
Niger 2012	Men	12.1
Cote d'Ivoire 2011-12	Women	12.2
Gambia 2013	Children	12.2
Yemen 2013	Women	12.4
Yemen 2013	Children	12.5
Sierra Leone 2013	Women	12.6
Egypt 2014	Women	12.7
Mozambique 2011	Women	12.8
Egypt 2014	Children	13.0
Nigeria 2015	Children	13.0
Benin 2011-12	Children	13.5
Niger 2012	Children	13.5
Timor-Leste 2009-10	Children	13.7
Timor-Leste 2009-10	Women	13.9
Benin 2011-12	Women	14.2
Sierra Leone 2013	Children	14.5
Angola 2011	Children	17.5

Figure A3.2 Distribution of the prevalence (percentage) of final digit 5 in the hemoglobin measurements for children age 6-59 months (80 surveys)[1], nonpregnant women age 15-49 (65 surveys)[2], and men (age range varies; 27 surveys)[2]. Expected value is 10%.



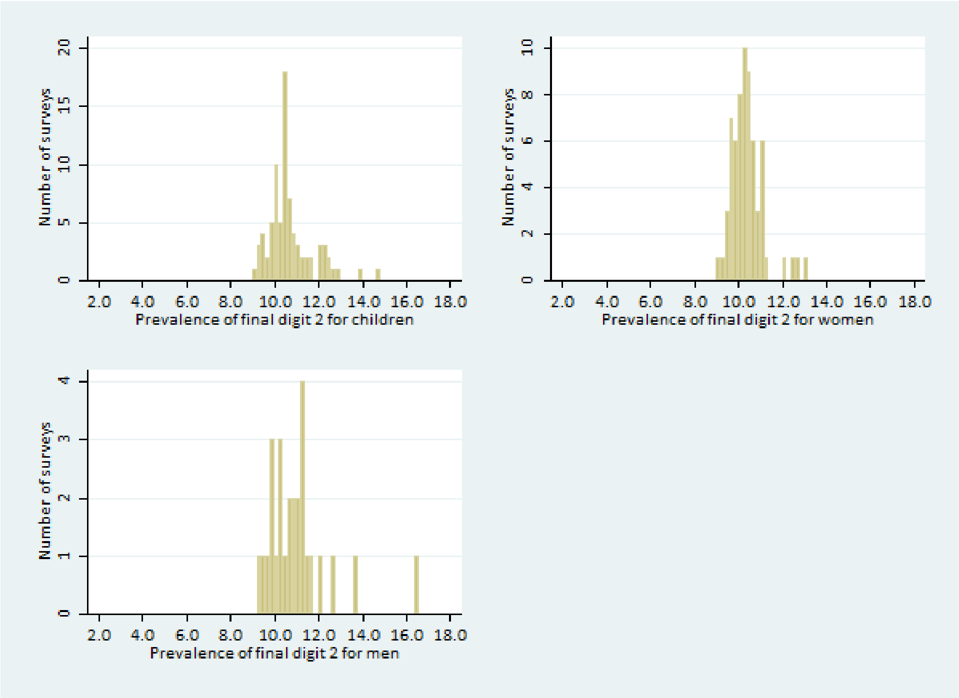
[1]Hemoglobin concentrations not adjusted for altitude >1000 meters

[2]Hemoglobin concentrations not adjusted for altitude >1000 meters and smoking >1 cigarette

Table A3.2 Surveys and subpopulations for which the frequency of final digit 5, if the unadjusted hemoglobin concentration, has the greatest deviation from 10%

Frequency of digit 5 is less than 8%:		
Armenia 2005	Children	7.5
Frequency of digit 5 is more than 12%:		
Benin 2011-12	Women	13.9

Figure A3.3 Distribution of the prevalence (percentage) of final digit 2 in the hemoglobin measurements for children age 6-59 months (80 surveys)[1], nonpregnant women age 15-49 (65 surveys)[2], and men (age range varies; 27 surveys)[2]. Expected value is 10%.

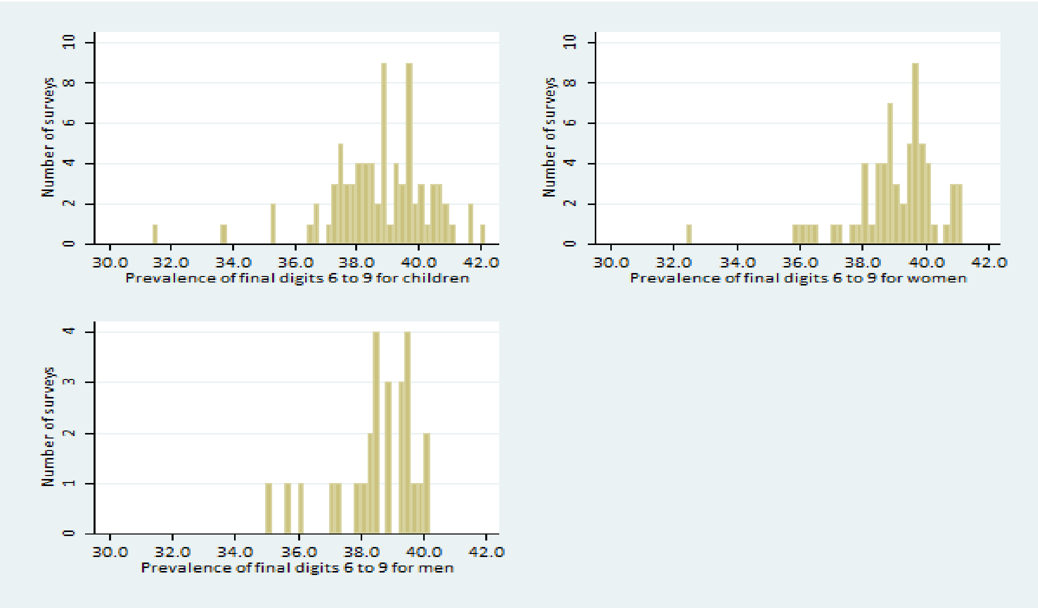


[1]Hemoglobin concentrations not adjusted for altitude
[2]Hemoglobin concentrations not adjusted for altitude and smoking

Table A3.3 Surveys and sub-populations for which the frequency of final digit 2, for the unadjusted hemoglobin concentration, has the greatest deviation from 10%

Frequency of digit 2 is less than 8%		
No surveys		
Frequency of digit 2 is more than 12%:		
Armenia 2005	Children	12.1
Sierra Leone 2008	Women	12.1
Guinea 2012	Children	12.1
Bangladesh 2011	Children	12.1
Niger 2012	Men	12.2
India 2005-06	Children	12.2
Lesotho 2014	Children	12.3
Benin 2006	Children	12.4
Guyana 2009	Children	12.4
Mali 2012-13	Children	12.5
Niger 2012	Women	12.6
Sierra Leone 2008	Children	12.6
Albania 2008-09	Women	12.7
Benin 2006	Men	12.8
Sierra Leone 2013	Children	13
Timor-Leste 2009-10	Women	13
Sierra Leone 2008	Men	13.8
Albania 2008-09	Children	13.9

Figure A3.4 Distribution of the prevalence (percentage) of final digit 6, 7, 8, 9 in the hemoglobin measurements for children age 6-59 months (80 surveys)[1], nonpregnant women age 15-49 (65 surveys)[2], and men (age range varies; 27 surveys)[2]. Expected value is 40%.



[1]Hemoglobin concentrations not adjusted for altitude
[2]Hemoglobin concentrations not adjusted for altitude and smoking

Table A3.4 Surveys and subpopulations for which the frequencies of final digits 6, 7, 8, and 9, for the unadjusted hemoglobin concentration, have t

Frequency of digits 6, 7, 8, and 9 is less than 38%:		
Timor-Leste 2009-10	Children	31.4
Timor-Leste 2009-10	Women	32.4
Sierra Leone 2013	Children	33.7
Sierra Leone 2008	Men	35.1
Sierra Leone 2008	Children	35.2
Moldova 2005	Children	35.3
Benin 2006	Men	35.7
Yemen 2013	Women	35.8
Benin 2011-12	Women	36
Niger 2012	Men	36
Sierra Leone 2008	Women	36.3
Egypt 2014	Women	36.4
Benin 2006	Children	36.5
Lesotho 2009	Children	36.6
Lesotho 2014	Children	36.6
Benin 2006	Women	37.1
Haiti 2012	Men	37.1
Guinea 2012	Children	37.2
Angola 2015-16	Children	37.2
Niger 2006	Men	37.2
Sierra Leone 2013	Women	37.3
Nigeria 2015	Children	37.4
Niger 2006	Children	37.4
Angola 2011	Children	37.4
Guyana 2009	Children	37.5
Haiti 2005-06	Children	37.5
Swaziland 2006-07	Children	37.6
Malawi 2014	Children	37.6
Yemen 2013	Children	37.6
Benin 2011-12	Children	37.7
Mozambique 2011	Women	37.8
Mali 2012-13	Children	37.8
Madagascar 2016	Children	37.8
Niger 2012	Women	37.9
Mozambique 2011	Children	37.9
Niger 2012	Children	37.9
Guinea 2012	Men	38
Frequency of digits 6, 7, 8, and 9 is more than 42%:		
Armenia 2005	Children	42.1

Appendix 4

Table A4.1 The mean, median, standard deviation, skew, and kurtosis of hemoglobin concentrations for children after removing values outside the range 4-18 g/dL

	Mean	Median	SD	Min	Max	Skew	Kurtosis
Albania 2008-09	11.81	12.00	1.15	6.30	17.20	-0.66	5.09
Angola 2011	10.74	10.80	1.42	4.00	15.50	-0.48	3.98
Angola 2015-16	10.40	10.50	1.42	4.10	15.70	-0.53	3.91
Armenia 2005	11.53	11.80	1.57	5.70	16.00	-0.72	3.78
Azerbaijan 2006	11.27	11.40	1.27	5.80	16.20	-0.42	3.92
Bangladesh 2011	10.80	10.90	1.23	4.70	14.70	-0.48	3.84
Benin 2006	9.64	9.80	1.69	4.00	17.60	-0.35	3.28
Benin 2011-12	10.50	10.60	1.56	4.10	17.70	-0.50	3.67
Bolivia 2003	10.85	11.00	1.56	4.30	16.20	-0.51	3.82
Bolivia 2008	10.51	10.60	1.60	4.40	16.60	-0.34	3.39
Burkina Faso 2010	9.04	9.10	1.66	4.00	15.90	-0.11	2.95
Burkina Faso 2014	9.02	9.10	1.74	4.10	15.20	-0.05	2.67
Burundi 2010	11.03	11.20	1.36	4.70	15.60	-0.58	3.90
Burundi 2012	10.79	11.00	1.56	4.40	15.10	-0.75	3.83
Cambodia 2010	10.74	10.80	1.33	4.70	15.10	-0.42	3.47
Cambodia 2014	10.72	10.80	1.28	4.50	15.20	-0.41	3.51
Cameroon 2004	10.07	10.20	1.73	4.00	15.40	-0.33	3.14
Cameroon 2011	10.43	10.50	1.52	4.60	15.10	-0.41	3.38
Congo 2005	10.34	10.40	1.48	4.40	15.50	-0.32	3.45
Congo 2011-12	10.38	10.50	1.33	4.20	14.90	-0.47	3.76
Congo DR 2007	10.09	10.20	1.68	4.10	17.30	-0.23	3.39
Congo DR 2013-14	10.29	10.40	1.70	4.00	17.60	-0.41	3.25
Cote d'Ivoire 2011-12	9.87	10.00	1.55	4.20	16.80	-0.20	3.09
Egypt 2014	11.45	11.50	1.17	5.40	15.90	-0.31	3.95
Ethiopia 2011	10.74	11.00	1.77	4.00	16.00	-0.64	3.49
Ethiopia 2016	10.38	10.50	1.73	4.10	18.00	-0.49	3.45
Gabon 2012	10.40	10.50	1.40	4.10	15.70	-0.52	3.55
Gambia 2013	9.81	10.00	1.57	4.00	14.70	-0.40	3.16
Ghana 2014	10.14	10.30	1.55	4.30	14.10	-0.37	3.01
Ghana 2016	10.24	10.40	1.49	4.00	14.80	-0.58	3.52
Guatemala 2014-15	11.42	11.50	1.31	4.20	15.80	-0.39	3.68
Guinea 2005	9.78	9.90	1.64	4.00	14.90	-0.42	3.25
Guinea 2012	9.73	9.90	1.72	4.00	14.50	-0.36	2.91
Guyana 2009	11.21	11.30	1.35	5.20	16.20	-0.43	3.92
Haiti 2005-06	10.47	10.60	1.56	4.00	16.80	-0.29	3.39
Haiti 2012	10.41	10.50	1.32	4.50	15.10	-0.30	3.24
Honduras 2005-06	11.29	11.40	1.30	4.00	16.80	-0.52	4.17
Honduras 2011-12	11.50	11.60	1.24	4.10	16.30	-0.41	3.84
India 2005-06	10.29	10.40	1.56	4.00	17.60	-0.41	3.39
Jordan 2009	11.41	11.50	1.37	6.00	15.60	-0.33	3.11
Jordan 2012	11.52	11.60	1.38	5.30	18.00	-0.36	3.45
Kenya 2015	11.24	11.30	1.51	4.90	16.50	-0.50	3.65
Kyrgyz Republic 2012	11.02	11.20	1.50	4.60	17.00	-0.70	3.96
Lesotho 2009	10.93	11.00	1.48	4.90	16.00	-0.52	3.73
Lesotho 2014	10.91	10.90	1.61	4.00	17.40	-0.05	3.72
Liberia 2011	9.95	10.00	1.49	4.60	14.90	-0.19	3.18
Madagascar 2013	10.91	11.00	1.47	4.10	15.70	-0.36	3.50
Madagascar 2016	11.08	11.10	1.41	4.90	16.40	-0.28	3.49
Malawi 2014	10.73	10.90	1.50	5.00	15.20	-0.54	3.50
Malawi 2015-16	10.40	10.50	1.47	4.20	17.10	-0.34	3.44
Mali 2012-13	9.43	9.50	1.74	4.00	15.80	-0.23	3.02
Mali 2015	9.28	9.40	1.64	4.00	16.90	-0.28	3.04
Moldova 2005	11.41	11.50	1.16	7.10	14.80	-0.31	3.54
Mozambique 2011	10.25	10.30	1.59	4.00	16.80	-0.34	3.38
Myanmar 2015-16	10.72	10.80	1.36	5.10	15.10	-0.42	3.48
Namibia 2013	10.91	11.00	1.43	5.30	16.50	-0.29	3.50
Nepal 2006	10.95	11.00	1.37	4.80	15.50	-0.42	3.50
Nepal 2011	11.03	11.10	1.35	5.00	15.40	-0.27	3.51
Niger 2006	9.47	9.50	1.73	4.00	17.40	0.17	4.07
Niger 2012	9.92	10.00	1.50	4.30	17.50	-0.22	3.54
Nigeria 2015	10.12	10.30	1.61	4.00	15.70	-0.41	3.25
Peru 2011	11.38	11.50	1.30	4.50	15.90	-0.60	3.99
Peru 2012	11.32	11.40	1.26	4.50	15.80	-0.56	3.86

Rwanda 2010	11.31	11.40	1.35	4.70	18.00	-0.23	4.94
Rwanda 2014-15	11.28	11.40	1.39	4.70	16.80	-0.64	4.26
ST and Principe 2008-09	10.62	10.70	1.27	4.90	15.30	-0.36	3.85
Senegal 2014	10.47	10.60	1.58	4.00	18.00	-0.41	3.60
Senegal 2015	10.08	10.20	1.51	4.00	15.10	-0.52	3.39
Sierra Leone 2008	9.94	10.10	1.52	4.00	15.30	-0.37	3.74
Sierra Leone 2013	9.59	9.80	1.61	4.00	17.00	-0.32	3.06
Swaziland 2006-07	11.19	11.30	1.53	4.10	15.80	-0.45	3.70
Tanzania 2010	10.53	10.60	1.43	4.10	15.40	-0.40	3.59
Tanzania 2015-16	10.59	10.70	1.47	4.00	17.40	-0.41	3.63
Timor-Leste 2009-10	11.14	11.20	1.23	4.40	16.50	-0.32	3.51
Togo 2013-14	10.10	10.10	1.51	4.70	14.80	-0.22	2.98
Uganda 2011	10.88	11.00	1.62	5.00	17.60	-0.34	3.24
Uganda 2014-15	10.71	10.80	1.60	4.30	15.80	-0.44	3.40
Yemen 2013	8.72	8.70	1.79	4.00	15.60	0.20	2.72
Zimbabwe 2010-11	10.63	10.70	1.43	4.50	14.80	-0.37	3.26
Zimbabwe 2015	11.29	11.40	1.33	5.60	16.70	-0.34	3.83

Note: Congo DR, Congo Democratic Republic; ST, Sao Tome; SD, Standard deviation; Hemoglobin adjusted for altitude prior to removing implausible values

Table A4.2 The mean, standard deviation, median, skew, and kurtosis of hemoglobin concentrations for children, including implausible values

	Mean	Median	SD	Min	Max	Skew	Kurtosis
Albania 2008-09	11.82	12.00	1.17	6.30	21.40	-0.24	7.82
Angola 2011	10.74	10.80	1.43	3.80	15.50	-0.50	4.09
Angola 2015-16	10.35	10.50	1.60	1.70	24.80	-0.96	9.99
Armenia 2005	11.51	11.70	1.63	1.80	16.00	-1.04	5.60
Azerbaijan 2006	11.26	11.40	1.30	2.40	16.20	-0.71	5.86
Bangladesh 2011	10.79	10.90	1.24	3.10	14.70	-0.57	4.36
Benin 2006	9.67	9.80	2.31	3.30	88.00	13.99	451.49
Benin 2011-12	10.46	10.60	1.67	0.00	17.70	-1.05	6.77
Bolivia 2003	10.84	11.00	1.57	2.70	16.20	-0.57	4.11
Bolivia 2008	10.49	10.60	1.65	0.00	18.80	-0.52	4.75
Burkina Faso 2010	9.02	9.10	1.68	2.70	15.90	-0.16	3.07
Burkina Faso 2014	9.02	9.00	1.75	3.10	15.20	-0.07	2.72
Burundi 2010	11.03	11.20	1.36	4.70	15.60	-0.58	3.90
Burundi 2012	10.77	11.00	1.60	2.80	18.50	-0.84	4.50
Cambodia 2010	10.73	10.80	1.34	3.70	15.10	-0.45	3.63
Cambodia 2014	10.72	10.80	1.28	4.50	15.20	-0.41	3.51
Cameroon 2004	10.08	10.20	2.00	2.30	67.20	6.53	195.92
Cameroon 2011	10.46	10.50	2.28	0.00	97.20	20.18	768.98
Congo 2005	10.37	10.40	2.29	0.50	85.50	18.19	604.40
Congo 2011-12	10.37	10.50	1.35	0.20	14.90	-0.60	4.64
Congo DR 2007	10.19	10.20	3.78	0.00	99.90	18.39	435.29
Congo DR 2013-14	10.29	10.40	1.71	2.40	19.80	-0.42	3.45
Cote d'Ivoire 2011-12	9.88	10.00	1.95	0.70	77.80	12.38	437.73
Egypt 2014	11.45	11.50	1.17	5.40	15.90	-0.31	3.95
Ethiopia 2011	10.74	10.90	2.16	0.50	94.20	10.14	392.28
Ethiopia 2016	10.37	10.50	1.76	0.90	19.50	-0.55	3.88
Gabon 2012	10.41	10.50	1.43	3.40	19.80	-0.38	4.69
Gambia 2013	9.79	9.90	1.60	1.00	14.70	-0.53	3.71
Ghana 2014	10.13	10.30	1.55	3.90	14.10	-0.38	3.07
Ghana 2016	10.24	10.40	1.50	2.00	14.80	-0.62	3.75
Guatemala 2014-15	11.42	11.50	1.32	3.80	22.80	-0.30	4.50
Guinea 2005	9.91	9.90	3.67	1.10	95.00	16.32	344.13
Guinea 2012	9.72	9.90	1.75	1.90	14.50	-0.43	3.14
Guyana 2009	11.20	11.30	1.39	0.80	16.20	-0.86	7.12
Haiti 2005-06	10.48	10.60	1.58	4.00	19.90	-0.16	4.03
Haiti 2012	10.41	10.50	1.32	3.60	15.10	-0.33	3.37
Honduras 2005-06	11.25	11.40	1.41	0.00	19.20	-1.39	10.32
Honduras 2011-12	11.75	11.60	4.92	0.70	99.90	16.67	298.85
India 2005-06	10.29	10.40	1.57	2.00	19.90	-0.40	3.65
Jordan 2009	11.41	11.50	1.37	6.00	15.60	-0.33	3.11
Jordan 2012	11.51	11.60	1.40	2.00	18.30	-0.51	4.64
Kenya 2015	11.24	11.30	1.52	3.00	18.50	-0.50	3.95
Kyrgyz Republic 2012	11.02	11.20	1.54	2.10	23.10	-0.58	5.56
Lesotho 2009	10.93	11.00	1.50	2.60	18.30	-0.56	4.46
Lesotho 2014	10.91	10.90	1.65	2.40	18.30	-0.15	4.48
Liberia 2011	9.95	10.00	1.49	4.60	14.90	-0.19	3.18
Madagascar 2013	10.90	11.00	1.52	0.90	15.70	-0.71	5.61
Madagascar 2016	11.07	11.10	1.42	2.90	18.50	-0.30	3.80
Malawi 2014	10.73	10.90	1.51	3.80	15.20	-0.57	3.65
Malawi 2015-16	10.39	10.50	1.50	1.80	17.10	-0.48	4.14
Mali 2012-13	9.42	9.50	1.79	0.60	29.80	0.07	7.01
Mali 2015	9.30	9.40	2.49	3.00	99.70	19.82	725.47
Moldova 2005	12.15	11.50	7.78	7.10	98.00	9.93	102.58
Mozambique 2011	10.26	10.30	1.88	0.80	78.00	9.49	354.21
Myanmar 2015-16	10.72	10.80	1.36	3.40	15.10	-0.45	3.64
Namibia 2013	10.90	11.00	1.45	3.20	16.50	-0.38	3.96
Nepal 2006	10.96	11.00	1.63	4.80	72.00	10.73	412.26
Nepal 2011	11.02	11.10	1.36	3.40	15.40	-0.34	3.87
Niger 2006	9.46	9.50	1.76	1.10	18.30	0.11	4.37
Niger 2012	9.92	10.00	1.51	2.90	20.20	-0.17	3.98
Nigeria 2015	10.12	10.30	1.61	3.60	15.70	-0.42	3.29
Peru 2011	11.38	11.50	1.32	-2.30	18.30	-0.75	5.72
Peru 2012	11.32	11.40	1.26	4.50	15.80	-0.56	3.86
Rwanda 2010	11.32	11.40	1.37	4.70	18.40	-0.10	5.38
Rwanda 2014-15	11.28	11.40	1.40	2.60	18.40	-0.65	4.71
ST and Principe 2008-09	10.59	10.70	1.36	0.30	15.30	-1.12	8.98
Senegal 2014	10.49	10.60	2.26	1.20	98.00	19.07	746.34

Senegal 2015	10.08	10.20	1.51	3.80	15.10	-0.53	3.44
Sierra Leone 2008	9.96	10.10	2.33	0.00	96.00	19.88	741.73
Sierra Leone 2013	9.61	9.80	2.39	2.10	99.70	20.21	768.22
Swaziland 2006-07	11.19	11.30	1.53	4.10	15.80	-0.45	3.70
Tanzania 2010	10.52	10.60	1.46	0.40	15.40	-0.59	4.70
Tanzania 2015-16	10.59	10.70	1.49	2.20	17.40	-0.49	4.02
Timor-Leste 2009-10	11.07	11.20	1.49	-0.30	16.50	-2.42	18.39
Togo 2013-14	10.09	10.10	1.52	2.20	14.80	-0.26	3.16
Uganda 2011	10.88	11.00	1.64	1.20	17.60	-0.48	4.02
Uganda 2014-15	10.70	10.80	1.60	3.60	15.80	-0.47	3.51
Yemen 2013	8.80	8.70	3.13	4.00	99.70	19.33	561.29
Zimbabwe 2010-11	10.65	10.70	1.88	3.30	67.90	11.62	348.90
Zimbabwe 2015	11.29	11.40	1.33	5.60	16.70	-0.34	3.83

Note: Congo DR, Congo Democratic Republic; ST, Sao Tome; SD, Standard deviation; Hemoglobin adjusted for altitude

Table A4.3 The mean, standard deviation, median, skew, and kurtosis of hemoglobin concentrations for nonpregnant women, after removing values outside the range 4-18 g/dL

	Mean	Median	SD	Min	Max	Skew	Kurtosis
Albania 2008-09	12.82	12.90	1.21	5.90	17.70	-0.71	5.72
Armenia 2005	12.86	13.00	1.46	4.00	17.20	-0.95	5.89
Azerbaijan 2006	12.26	12.40	1.55	4.00	17.20	-0.95	5.24
Bangladesh 2011	12.17	12.20	1.35	5.30	17.90	-0.38	3.80
Benin 2006	11.45	11.50	1.59	4.40	16.20	-0.45	3.68
Benin 2011-12	12.20	12.30	1.53	5.40	18.00	-0.22	3.55
Bolivia 2003	12.56	12.70	1.59	4.40	17.50	-0.57	4.12
Bolivia 2008	12.35	12.50	1.63	4.20	17.40	-0.54	4.14
Burkina Faso 2010	11.89	12.10	1.75	4.10	17.60	-0.56	3.69
Burundi 2010	13.28	13.40	1.50	5.40	17.70	-0.65	4.29
Cambodia 2010	12.10	12.20	1.42	4.00	17.40	-0.48	4.24
Cambodia 2014	12.07	12.10	1.34	4.00	17.30	-0.55	4.46
Cameroon 2004	12.08	12.20	1.73	4.40	17.80	-0.47	3.80
Cameroon 2011	12.24	12.40	1.63	4.60	17.10	-0.57	3.99
Congo 2005	11.57	11.70	1.50	4.50	16.00	-0.54	3.78
Congo 2011-12	11.79	11.90	1.41	5.70	16.50	-0.31	3.53
Congo DR 2007	11.87	11.95	1.77	4.10	17.80	-0.37	3.62
Congo DR 2013-14	12.24	12.30	1.57	4.30	17.70	-0.35	3.67
Cote d'Ivoire 2011-12	11.74	11.80	1.62	4.00	16.80	-0.44	3.70
Egypt 2014	12.58	12.60	1.12	6.20	18.00	-0.43	5.14
Ethiopia 2011	13.17	13.40	1.73	4.20	18.00	-0.99	5.23
Ethiopia 2016	12.78	13.00	1.77	4.30	18.00	-0.88	4.57
Gabon 2012	11.49	11.60	1.59	4.50	18.00	-0.51	3.71
Gambia 2013	11.33	11.50	1.73	4.10	16.60	-0.59	3.72
Ghana 2014	12.10	12.20	1.48	4.70	17.10	-0.55	3.88
Guatemala 2014-15	13.31	13.40	1.41	4.40	18.00	-0.74	5.08
Guinea 2005	11.78	11.90	1.72	5.20	17.90	-0.48	3.50
Guinea 2012	11.87	12.00	1.61	4.20	16.60	-0.63	4.17
Guyana 2009	12.30	12.50	1.57	5.40	17.60	-0.70	4.10
Haiti 2005-06	11.99	12.20	1.83	4.00	16.90	-0.75	3.87
Haiti 2012	11.86	12.00	1.60	4.00	16.70	-0.73	4.44
Honduras 2005-06	13.11	13.20	1.40	4.00	17.80	-0.70	4.96
Honduras 2011-12	13.21	13.30	1.36	4.60	17.90	-0.65	4.82
India 2005-06	11.69	11.90	1.73	4.00	18.00	-0.71	4.09
Jordan 2009	12.72	12.90	1.48	5.70	17.20	-0.67	4.03
Jordan 2012	12.42	12.60	1.59	4.60	17.80	-0.62	3.76
Kyrgyz Republic 2012	12.31	12.50	1.65	4.10	17.50	-0.95	4.69
Lesotho 2009	12.87	13.10	1.73	4.20	18.00	-0.78	4.26
Lesotho 2014	12.87	13.00	1.80	4.20	17.90	-0.69	4.09
Malawi 2015-16	12.50	12.60	1.65	4.30	17.70	-0.63	4.28
Mali 2012-13	11.78	11.90	1.62	4.20	17.10	-0.56	3.97
Moldova 2005	12.58	12.70	1.36	4.90	16.90	-0.74	4.77
Mozambique 2011	11.72	11.90	1.75	4.00	17.80	-0.52	4.05
Myanmar 2015-16	12.05	12.10	1.52	4.10	17.40	-0.55	4.22
Namibia 2013	13.08	13.20	1.61	4.50	17.70	-0.64	4.40
Nepal 2006	12.46	12.60	1.55	4.40	17.60	-0.56	4.08
Nepal 2011	12.57	12.70	1.53	4.00	17.40	-0.53	4.08
Niger 2006	12.15	12.30	1.87	4.10	17.70	-0.47	3.95
Niger 2012	12.07	12.20	1.60	4.10	17.00	-0.62	4.17
Peru 2011	13.05	13.20	1.37	4.10	17.90	-0.89	5.59
Peru 2012	12.98	13.10	1.33	4.60	18.00	-0.77	5.23
Rwanda 2010	13.31	13.50	1.53	4.70	17.90	-0.74	4.39
Rwanda 2014-15	13.10	13.20	1.50	4.80	17.70	-0.68	4.52
ST and Principe 2008-09	12.13	12.20	1.52	5.90	16.30	-0.47	3.86
Sierra Leone 2008	11.97	12.10	1.64	4.40	17.40	-0.50	3.57
Sierra Leone 2013	12.01	12.10	1.58	4.10	17.80	-0.39	3.93
Swaziland 2006-07	12.65	12.80	1.69	5.20	17.60	-0.61	3.83
Tanzania 2010	12.11	12.30	1.73	4.10	17.40	-0.69	4.17
Tanzania 2015-16	11.99	12.10	1.68	4.20	17.40	-0.61	4.13
Timor-Leste 2009-10	12.79	12.90	1.41	4.40	17.80	-0.76	5.31
Togo 2013-14	12.06	12.20	1.60	4.20	17.30	-0.54	4.19
Uganda 2011	13.00	13.10	1.67	4.00	17.60	-0.81	4.97
Yemen 2013	10.66	10.80	1.91	4.20	17.00	-0.12	2.91
Zimbabwe 2010-11	12.72	12.90	1.83	4.50	17.90	-0.68	3.90
Zimbabwe 2015	12.74	12.90	1.72	4.00	17.80	-0.80	4.49

Note: Congo DR, Congo Democratic Republic; ST, Sao Tome; SD, Standard deviation; Hemoglobin adjusted for altitude and smoking prior to removing implausible values

Table A4.4 The mean, standard deviation, median, skew, and kurtosis of hemoglobin concentrations for nonpregnant women, including implausible values

	Mean	Median	SD	Min	Max	Skew	Kurtosis
Albania 2008-09	12.83	12.90	1.21	5.90	19.90	-0.68	5.82
Armenia 2005	12.86	13.00	1.83	1.20	92.90	13.37	619.80
Azerbaijan 2006	12.25	12.40	1.57	1.70	18.40	-1.03	5.84
Bangladesh 2011	12.17	12.20	1.35	5.30	17.90	-0.38	3.80
Benin 2006	11.46	11.50	2.07	0.20	98.00	15.88	677.37
Benin 2011-12	12.16	12.30	1.67	0.00	18.00	-1.19	9.62
Bolivia 2003	12.56	12.70	1.61	1.50	18.50	-0.63	4.72
Bolivia 2008	12.35	12.50	1.65	1.20	19.30	-0.58	4.75
Burkina Faso 2010	11.89	12.10	1.75	3.80	19.70	-0.55	3.79
Burundi 2010	13.28	13.40	1.51	5.40	19.40	-0.62	4.33
Cambodia 2010	12.10	12.20	1.72	0.20	85.00	10.01	410.93
Cambodia 2014	12.07	12.10	1.34	4.00	17.30	-0.55	4.46
Cameroon 2004	12.08	12.20	1.74	3.20	17.80	-0.54	4.14
Cameroon 2011	12.24	12.40	1.64	0.00	18.80	-0.63	4.47
Congo 2005	11.56	11.70	1.54	0.50	19.90	-0.74	5.76
Congo 2011-12	11.80	11.90	1.48	5.70	43.20	1.73	45.49
Congo DR 2007	12.11	12.00	5.04	-0.40	99.90	14.23	242.78
Congo DR 2013-14	12.26	12.30	2.10	2.10	99.70	17.49	737.61
Cote d'Ivoire 2011-12	11.74	11.80	1.66	0.20	18.70	-0.54	4.67
Egypt 2014	12.58	12.60	1.12	6.20	18.00	-0.43	5.14
Ethiopia 2011	13.17	13.40	1.87	2.10	90.50	4.10	210.36
Ethiopia 2016	12.78	13.00	1.78	3.40	19.40	-0.88	4.68
Gabon 2012	11.50	11.60	2.00	3.30	95.00	14.64	625.39
Gambia 2013	11.34	11.50	1.96	2.70	69.10	5.56	180.24
Ghana 2014	12.09	12.20	1.49	3.10	17.10	-0.62	4.32
Guatemala 2014-15	13.31	13.40	1.42	4.40	24.90	-0.68	5.34
Guinea 2005	11.76	11.90	1.76	1.10	18.80	-0.65	4.54
Guinea 2012	11.87	12.00	1.62	3.90	16.60	-0.65	4.26
Guyana 2009	12.34	12.50	2.30	3.90	96.00	15.89	521.93
Haiti 2005-06	11.99	12.20	1.85	2.80	19.90	-0.74	4.12
Haiti 2012	11.86	12.00	1.63	0.80	18.80	-0.87	5.37
Honduras 2005-06	13.09	13.20	1.52	0.80	48.80	-0.25	28.52
Honduras 2011-12	13.54	13.30	5.46	4.60	99.90	14.78	234.26
India 2005-06	11.69	11.90	1.74	2.00	22.90	-0.74	4.37
Jordan 2009	12.72	12.90	1.49	5.70	30.80	-0.39	7.02
Jordan 2012	12.42	12.60	1.60	4.60	31.20	-0.43	5.56
Kyrgyz Republic 2012	12.31	12.50	1.67	2.60	21.80	-0.91	5.16
Lesotho 2009	12.87	13.10	1.74	3.80	18.70	-0.78	4.42
Lesotho 2014	12.86	13.00	1.83	2.40	18.10	-0.81	4.84
Malawi 2015-16	12.50	12.60	1.68	2.20	22.80	-0.65	5.06
Mali 2012-13	11.77	11.90	1.65	1.00	17.10	-0.72	4.95
Moldova 2005	12.82	12.70	4.52	0.00	98.00	15.62	273.95
Mozambique 2011	11.71	11.85	1.76	2.10	18.30	-0.57	4.32
Myanmar 2015-16	12.04	12.10	1.53	2.50	21.10	-0.56	4.47
Namibia 2013	13.08	13.20	1.62	1.30	18.40	-0.68	4.89
Nepal 2006	12.46	12.60	1.56	3.20	17.60	-0.58	4.18
Nepal 2011	12.57	12.70	1.54	3.60	18.70	-0.54	4.26
Niger 2006	12.14	12.30	1.90	0.20	20.00	-0.52	4.58
Niger 2012	12.08	12.20	1.82	3.40	69.00	6.41	217.99
Peru 2011	13.05	13.20	1.40	1.00	41.70	-0.65	15.00
Peru 2012	12.98	13.10	1.34	2.20	21.20	-0.77	5.53
Rwanda 2010	13.31	13.50	1.54	2.20	18.30	-0.81	4.95
Rwanda 2014-15	13.10	13.20	1.50	4.80	18.80	-0.66	4.55
ST and Principe 2008-09	12.13	12.20	1.52	5.90	16.30	-0.47	3.86
Sierra Leone 2008	11.97	12.10	1.83	-0.30	49.30	2.17	61.89
Sierra Leone 2013	12.02	12.10	1.89	3.10	99.70	13.49	641.51
Swaziland 2006-07	12.66	12.80	1.70	5.20	19.40	-0.55	3.92
Tanzania 2010	12.11	12.30	1.84	3.20	68.00	2.55	100.25
Tanzania 2015-16	11.98	12.10	1.70	1.90	24.00	-0.67	4.78
Timor-Leste 2009-10	12.79	12.90	1.44	3.60	22.20	-0.81	6.62
Togo 2013-14	12.06	12.20	1.60	4.20	19.10	-0.52	4.24
Uganda 2011	13.00	13.10	1.68	3.80	17.60	-0.85	5.22
Yemen 2013	10.74	10.80	3.33	2.00	99.70	17.71	474.31
Zimbabwe 2010-11	12.72	12.90	2.05	0.90	83.10	4.96	191.13
Zimbabwe 2015	12.74	12.90	1.74	2.90	19.00	-0.87	4.92

Note: Congo DR, Congo Democratic Republic; ST, Sao Tome; SD, Standard deviation; Hemoglobin adjusted for altitude and smoking

Table A4.5 The mean, standard deviation, median, skew, and kurtosis of hemoglobin concentrations for men, after removing values outside the range 4-20 g/dL

	Mean	Median	SD	Min	Max	Skew	Kurtosis
Albania 2008-09	14.08	14.10	1.29	9.10	19.80	0.15	3.42
Benin 2006	13.50	13.60	1.91	5.00	19.80	-0.43	3.89
Burkina Faso 2010	13.84	14.00	1.89	4.00	19.80	-0.46	3.71
Burundi 2010	15.05	15.10	1.72	5.20	19.90	-0.48	3.87
Congo DR 2007	13.37	13.40	2.02	4.20	19.80	-0.29	3.57
Congo DR 2013-14	14.07	14.20	1.86	4.00	19.90	-0.39	3.66
Cote d'Ivoire 2011-12	13.91	14.00	1.90	5.30	19.90	-0.39	3.42
Ethiopia 2011	14.98	15.10	1.86	4.00	20.00	-0.77	4.88
Ethiopia 2016	14.66	14.80	1.91	4.30	20.00	-0.82	4.79
Gabon 2012	13.78	13.80	1.73	4.00	19.90	-0.40	4.15
Guinea 2012	13.91	14.00	1.74	5.80	20.00	-0.51	4.12
Guyana 2009	14.37	14.40	1.60	5.30	19.90	-0.53	4.72
Haiti 2005-06	13.95	14.20	1.90	4.10	19.70	-0.90	4.94
Haiti 2012	13.88	14.00	1.63	4.10	19.90	-0.64	4.96
India 2005-06	14.22	14.40	1.82	4.00	20.00	-0.72	4.77
Lesotho 2009	14.90	15.00	1.77	5.80	20.00	-0.71	4.51
Lesotho 2014	14.79	14.90	1.84	5.80	19.90	-0.60	3.99
Namibia 2013	14.91	15.00	1.73	6.80	19.70	-0.39	3.66
Niger 2006	14.28	14.40	1.94	4.50	19.80	-0.49	3.89
Niger 2012	13.99	14.10	1.69	5.50	19.40	-0.48	4.06
ST and Principe 2008-09	13.93	14.00	1.76	4.90	19.60	-0.48	4.38
Sierra Leone 2008	13.36	13.50	1.89	4.60	19.30	-0.39	3.56
Sierra Leone 2013	13.56	13.60	1.81	4.40	19.40	-0.41	3.96
Swaziland 2006-07	14.84	15.00	1.70	5.40	20.00	-0.65	4.64
Togo 2013-14	14.28	14.40	1.81	4.10	19.90	-0.58	4.57
Zimbabwe 2010-11	14.70	14.90	1.86	4.20	19.90	-0.65	4.22
Zimbabwe 2015	14.61	14.70	1.70	4.50	20.00	-0.46	4.02

Note: Congo DR, Congo Democratic Republic; ST, Sao Tome; SD, Standard deviation; Hemoglobin adjusted for altitude and smoking prior to removing implausible values

Table A4.6 The mean, standard deviation, median, skew, and kurtosis of hemoglobin concentrations for men, including implausible values

	Mean	Median	SD	Min	Max	Skew	Kurtosis
Albania 2008-09	14.08	14.10	1.29	9.10	19.80	0.15	3.42
Benin 2006	13.54	13.60	2.58	3.70	98.00	13.84	444.25
Burkina Faso 2010	13.83	14.00	1.89	3.30	19.80	-0.48	3.81
Burundi 2010	15.04	15.10	1.74	1.90	20.10	-0.56	4.56
Congo DR 2007	13.68	13.40	5.55	-0.40	99.90	13.09	202.04
Congo DR 2013-14	14.09	14.20	2.28	3.20	99.70	11.97	459.18
Cote d'Ivoire 2011-12	13.91	14.00	1.90	5.30	20.40	-0.38	3.44
Ethiopia 2011	14.98	15.10	1.89	2.60	26.10	-0.83	5.60
Ethiopia 2016	14.66	14.80	1.94	1.80	22.40	-0.85	5.24
Gabon 2012	13.80	13.80	2.06	4.00	95.50	11.17	455.91
Guinea 2012	13.91	14.00	1.78	3.10	23.80	-0.48	5.04
Guyana 2009	14.38	14.40	1.62	5.30	23.60	-0.46	4.98
Haiti 2005-06	13.95	14.20	1.90	3.70	19.70	-0.92	5.06
Haiti 2012	13.88	14.00	1.63	3.80	20.10	-0.67	5.19
India 2005-06	14.22	14.40	1.84	2.20	23.80	-0.75	5.10
Lesotho 2009	14.91	15.00	1.78	5.80	22.30	-0.64	4.60
Lesotho 2014	14.78	14.90	1.89	2.10	20.20	-0.84	5.63
Namibia 2013	14.91	15.00	1.75	3.90	21.80	-0.41	4.04
Niger 2006	14.27	14.40	1.99	1.40	22.20	-0.65	5.14
Niger 2012	14.00	14.10	1.70	5.50	23.40	-0.38	4.39
ST and Principe 2008-09	13.93	14.00	1.76	4.90	19.60	-0.48	4.38
Sierra Leone 2008	13.36	13.50	1.96	-0.50	22.40	-0.57	5.53
Sierra Leone 2013	13.57	13.60	2.09	4.40	99.70	9.96	424.74
Swaziland 2006-07	14.84	15.00	1.71	5.40	20.70	-0.62	4.67
Togo 2013-14	14.28	14.40	1.83	2.10	21.30	-0.59	4.97
Zimbabwe 2010-11	14.74	14.90	2.20	2.80	63.30	4.65	100.33
Zimbabwe 2015	14.61	14.70	1.71	2.10	21.90	-0.52	4.53

Note: Congo DR, Congo Democratic Republic; ST, Sao Tome; Standard deviation; Hemoglobin adjusted for altitude and smoking

Appendix 5

Table A.5.1 Mean, standard deviation, and median hemoglobin concentrations g/dL for children, after removing values outside the range 4-18 g/dL, by age

	6-11 months			12-23 months			24-59 months		
	Mean	Median	SD	Mean	Median	SD	Mean	Median	SD
Albania 2008-09	11.49	11.70	1.21	11.40	11.60	1.21	11.96	12.10	1.08
Angola 2011	10.12	10.10	1.39	10.36	10.40	1.35	10.99	11.10	1.39
Angola 2015-16	9.85	10.00	1.24	10.05	10.20	1.38	10.60	10.70	1.42
Armenia 2005	10.39	10.50	1.76	11.06	11.20	1.57	11.87	12.00	1.40
Azerbaijan 2006	10.77	10.70	1.22	10.80	11.00	1.31	11.52	11.60	1.19
Bangladesh 2011	10.10	10.20	1.24	10.27	10.30	1.24	11.07	11.20	1.13
Benin 2006	9.12	9.30	1.83	9.24	9.40	1.69	9.88	10.00	1.62
Benin 2011-12	10.15	10.30	1.66	10.20	10.40	1.62	10.64	10.80	1.51
Bolivia 2003	9.86	10.00	1.45	10.07	10.20	1.61	11.18	11.30	1.42
Bolivia 2008	9.86	9.90	1.55	9.76	9.80	1.59	10.85	11.00	1.49
Burkina Faso 2010	8.48	8.50	1.63	8.45	8.50	1.62	9.33	9.40	1.60
Burkina Faso 2014	8.66	8.70	1.61	8.42	8.40	1.67	9.27	9.30	1.72
Burundi 2010	10.21	10.20	1.29	10.83	10.90	1.28	11.24	11.40	1.34
Burundi 2012	9.89	10.00	1.47	10.59	10.80	1.49	11.00	11.20	1.55
Cambodia 2010	9.80	9.90	1.22	10.15	10.20	1.34	11.09	11.20	1.19
Cambodia 2014	10.00	10.00	1.22	10.21	10.30	1.34	11.02	11.10	1.16
Cameroon 2004	9.44	9.50	1.83	9.50	9.60	1.74	10.41	10.50	1.62
Cameroon 2011	9.88	10.00	1.42	10.12	10.30	1.49	10.65	10.80	1.50
Congo 2005	9.86	10.10	1.50	10.04	10.20	1.54	10.54	10.50	1.41
Congo 2011-12	9.79	9.80	1.19	10.02	10.10	1.26	10.61	10.70	1.33
Congo DR 2007	9.27	9.40	1.70	9.82	9.90	1.66	10.32	10.40	1.62
Congo DR 2013-14	9.84	10.00	1.61	10.15	10.30	1.71	10.41	10.60	1.69
Cote d'Ivoire 2011-12	9.30	9.40	1.47	9.43	9.50	1.50	10.13	10.20	1.52
Egypt 2014	10.95	11.00	1.25	11.07	11.20	1.19	11.69	11.70	1.07
Ethiopia 2011	10.08	10.20	1.63	10.18	10.40	1.75	11.00	11.20	1.74
Ethiopia 2016	9.83	10.00	1.51	9.90	10.00	1.67	10.63	10.80	1.73
Gabon 2012	10.19	10.20	1.37	10.10	10.20	1.37	10.56	10.70	1.39
Gambia 2013	9.57	9.70	1.30	9.20	9.30	1.47	10.07	10.20	1.59
Ghana 2014	9.73	9.80	1.49	9.70	9.80	1.55	10.34	10.40	1.51
Ghana 2016	9.82	9.90	1.46	9.77	9.90	1.49	10.47	10.60	1.45
Guatemala 2014-15	10.25	10.30	1.25	10.90	10.90	1.31	11.76	11.80	1.16
Guinea 2005	9.41	9.60	1.78	9.11	9.20	1.66	10.06	10.10	1.53
Guinea 2012	9.40	9.50	1.67	9.24	9.40	1.71	9.94	10.20	1.70
Guyana 2009	10.57	10.50	1.37	10.82	10.90	1.40	11.44	11.50	1.26
Haiti 2005-06	9.94	9.90	1.51	9.93	10.00	1.52	10.75	10.90	1.51
Haiti 2012	9.72	9.70	1.22	9.96	10.10	1.31	10.69	10.80	1.25
Honduras 2005-06	10.45	10.50	1.21	10.80	10.90	1.29	11.56	11.60	1.21
Honduras 2011-12	10.73	10.80	1.22	11.07	11.20	1.26	11.78	11.80	1.13
India 2005-06	9.94	10.00	1.38	9.72	9.80	1.53	10.52	10.70	1.54
Jordan 2009	10.74	10.80	1.35	10.87	11.00	1.31	11.72	11.80	1.29
Jordan 2012	10.90	11.00	1.27	11.00	11.10	1.39	11.78	11.90	1.31
Kenya 2015	10.74	10.80	1.45	10.61	10.70	1.40	11.50	11.60	1.47
Kyrgyz Republic 2012	10.56	10.70	1.41	10.47	10.70	1.59	11.30	11.40	1.41
Lesotho 2009	10.37	10.60	1.57	10.46	10.50	1.51	11.16	11.30	1.39
Lesotho 2014	10.63	10.60	1.61	10.47	10.50	1.71	11.08	11.10	1.55
Liberia 2011	9.75	9.80	1.30	9.71	9.70	1.50	10.05	10.10	1.50
Madagascar 2013	10.02	10.00	1.34	10.37	10.40	1.47	11.21	11.30	1.39
Madagascar 2016	10.18	10.20	1.30	10.51	10.50	1.38	11.37	11.40	1.32
Malawi 2014	10.15	10.30	1.47	10.26	10.40	1.44	11.00	11.20	1.46
Malawi 2015-16	9.57	9.60	1.40	9.92	10.00	1.40	10.68	10.80	1.42
Mali 2012-13	9.38	9.50	1.46	8.96	9.00	1.69	9.58	9.70	1.76
Mali 2015	9.35	9.50	1.45	8.81	8.90	1.55	9.41	9.60	1.67
Moldova 2005	10.91	10.90	1.02	11.01	11.10	1.13	11.64	11.70	1.12
Mozambique 2011	9.72	9.90	1.53	9.80	9.90	1.58	10.51	10.60	1.54
Myanmar 2015-16	10.11	10.20	1.36	10.12	10.20	1.36	10.99	11.10	1.27
Namibia 2013	10.39	10.50	1.54	10.32	10.40	1.43	11.19	11.30	1.33
Nepal 2006	9.97	10.00	1.29	10.30	10.40	1.28	11.29	11.40	1.27
Nepal 2011	10.10	10.20	1.15	10.45	10.50	1.22	11.33	11.30	1.30
Niger 2006	9.30	9.30	1.47	8.85	8.90	1.61	9.70	9.80	1.75
Niger 2012	9.52	9.60	1.44	9.28	9.30	1.39	10.17	10.20	1.48
Nigeria 2015	9.87	10.00	1.54	9.78	9.90	1.59	10.27	10.40	1.61
Peru 2011	10.26	10.40	1.33	10.76	10.90	1.34	11.73	11.80	1.12

Peru 2012	10.35	10.40	1.35	10.70	10.80	1.29	11.65	11.70	1.09
Rwanda 2010	10.21	10.30	1.28	10.95	10.90	1.30	11.58	11.60	1.26
Rwanda 2014-15	10.34	10.50	1.42	11.03	11.20	1.32	11.53	11.60	1.32
ST and Principe 2008-09	9.97	10.10	1.23	10.08	10.20	1.31	10.93	11.00	1.15
Senegal 2014	10.31	10.30	1.26	9.94	10.00	1.49	10.66	10.80	1.60
Senegal 2015	9.96	10.00	1.23	9.44	9.50	1.42	10.30	10.50	1.52
Sierra Leone 2008	9.64	9.90	1.66	9.62	9.80	1.55	10.09	10.10	1.47
Sierra Leone 2013	9.33	9.50	1.56	9.31	9.50	1.63	9.70	9.90	1.60
Swaziland 2006-07	10.37	10.50	1.38	10.35	10.50	1.58	11.60	11.70	1.36
Tanzania 2010	9.92	10.00	1.31	10.11	10.10	1.41	10.76	10.90	1.39
Tanzania 2015-16	9.88	10.00	1.42	10.14	10.20	1.40	10.88	11.00	1.42
Timor-Leste 2009-10	10.45	10.40	1.21	10.79	10.90	1.31	11.35	11.40	1.14
Togo 2013-14	9.46	9.60	1.32	9.62	9.70	1.46	10.37	10.50	1.49
Uganda 2011	10.22	10.30	1.50	10.41	10.60	1.51	11.17	11.30	1.61
Uganda 2014-15	9.69	9.90	1.61	10.26	10.30	1.50	10.99	11.10	1.53
Yemen 2013	8.40	8.30	1.71	8.28	8.20	1.72	8.92	8.90	1.80
Zimbabwe 2010-11	10.00	10.00	1.49	10.15	10.20	1.38	10.91	11.00	1.36
Zimbabwe 2015	10.55	10.70	1.27	10.79	10.90	1.39	11.54	11.60	1.24

Note: Congo DR, Congo Democratic Republic; ST, Sao Tome; SD, Standard deviation; Hemoglobin adjusted for altitude prior to removing implausible values

Table A.5.2 Mean, standard deviation, and median hemoglobin concentrations g/dL for children after removing values outside the range 4-18 g/dL, by sex

	Male			Female		
	Mean	Median	SD	Mean	Median	SD
Albania 2008-09	11.79	12.00	1.19	11.83	12.00	1.10
Angola 2011	10.65	10.80	1.43	10.82	11.00	1.42
Angola 2015-16	10.34	10.40	1.43	10.45	10.60	1.41
Armenia 2005	11.54	11.80	1.60	11.52	11.70	1.52
Azerbaijan 2006	11.22	11.30	1.25	11.34	11.40	1.29
Bangladesh 2011	10.76	10.90	1.26	10.83	10.90	1.21
Benin 2006	9.56	9.70	1.71	9.73	9.90	1.67
Benin 2011-12	10.47	10.60	1.63	10.53	10.70	1.49
Bolivia 2003	10.80	11.00	1.58	10.90	11.00	1.53
Bolivia 2008	10.46	10.60	1.61	10.56	10.70	1.58
Burkina Faso 2010	8.96	9.10	1.66	9.11	9.20	1.66
Burkina Faso 2014	8.93	9.00	1.75	9.12	9.20	1.72
Burundi 2010	10.97	11.10	1.37	11.08	11.20	1.35
Burundi 2012	10.72	10.90	1.53	10.85	11.10	1.60
Cambodia 2010	10.68	10.80	1.37	10.80	10.90	1.29
Cambodia 2014	10.67	10.80	1.32	10.77	10.80	1.23
Cameroon 2004	9.98	10.10	1.71	10.17	10.30	1.75
Cameroon 2011	10.37	10.40	1.50	10.50	10.60	1.53
Congo 2005	10.30	10.30	1.53	10.39	10.50	1.42
Congo 2011-12	10.33	10.50	1.35	10.43	10.50	1.32
Congo DR 2007	10.02	10.10	1.66	10.17	10.30	1.69
Congo DR 2013-14	10.25	10.40	1.70	10.33	10.50	1.69
Cote d'Ivoire 2011-12	9.81	10.00	1.57	9.93	10.00	1.52
Egypt 2014	11.48	11.50	1.24	11.42	11.50	1.09
Ethiopia 2011	10.71	10.90	1.79	10.78	11.00	1.76
Ethiopia 2016	10.35	10.50	1.75	10.42	10.60	1.72
Gabon 2012	10.30	10.40	1.43	10.51	10.60	1.36
Gambia 2013	9.76	9.90	1.58	9.86	10.00	1.56
Ghana 2014	10.08	10.20	1.57	10.19	10.30	1.52
Ghana 2016	10.14	10.30	1.51	10.35	10.50	1.47
Guatemala 2014-15	11.42	11.50	1.32	11.42	11.50	1.30
Guinea 2005	9.75	9.90	1.67	9.81	9.90	1.61
Guinea 2012	9.68	9.80	1.72	9.78	10.00	1.73
Guyana 2009	11.21	11.30	1.39	11.22	11.30	1.30
Haiti 2005-06	10.40	10.50	1.56	10.55	10.70	1.57
Haiti 2012	10.40	10.50	1.36	10.43	10.50	1.27
Honduras 2005-06	11.25	11.30	1.32	11.33	11.40	1.27
Honduras 2011-12	11.47	11.60	1.27	11.53	11.60	1.20
India 2005-06	10.27	10.40	1.58	10.31	10.40	1.54
Jordan 2009	11.37	11.50	1.39	11.45	11.60	1.34
Jordan 2012	11.47	11.50	1.43	11.58	11.60	1.32
Kenya 2015	11.15	11.30	1.51	11.33	11.40	1.50
Kyrgyz Republic 2012	11.01	11.20	1.51	11.04	11.20	1.50
Lesotho 2009	10.94	11.00	1.44	10.92	11.00	1.51
Lesotho 2014	10.90	10.90	1.61	10.93	11.00	1.62
Liberia 2011	9.88	9.90	1.50	10.01	10.10	1.47
Madagascar 2013	10.88	11.00	1.51	10.95	11.00	1.42
Madagascar 2016	11.04	11.10	1.43	11.12	11.20	1.38
Malawi 2014	10.71	10.80	1.53	10.76	10.90	1.47
Malawi 2015-16	10.35	10.50	1.52	10.45	10.50	1.42
Mali 2012-13	9.38	9.50	1.73	9.49	9.60	1.74
Mali 2015	9.22	9.30	1.62	9.34	9.50	1.66
Moldova 2005	11.42	11.50	1.18	11.39	11.40	1.14
Mozambique 2011	10.22	10.30	1.62	10.28	10.40	1.56
Myanmar 2015-16	10.66	10.80	1.41	10.79	10.90	1.30
Namibia 2013	10.84	10.90	1.43	10.97	11.10	1.43
Nepal 2006	10.95	11.10	1.40	10.95	11.00	1.35
Nepal 2011	11.12	11.20	1.32	10.93	11.00	1.38
Niger 2006	9.45	9.50	1.76	9.49	9.60	1.70
Niger 2012	9.87	10.00	1.54	9.97	10.00	1.46
Nigeria 2015	10.05	10.20	1.60	10.20	10.30	1.61
Peru 2011	11.32	11.40	1.33	11.45	11.50	1.28
Peru 2012	11.28	11.40	1.32	11.35	11.40	1.21
Rwanda 2010	11.24	11.30	1.40	11.39	11.40	1.28
Rwanda 2014-15	11.23	11.40	1.41	11.34	11.40	1.37
ST and Principe 2008-09	10.57	10.60	1.33	10.66	10.80	1.21

Senegal 2014	10.42	10.50	1.60	10.52	10.60	1.55
Senegal 2015	10.00	10.20	1.53	10.15	10.30	1.49
Sierra Leone 2008	9.86	10.00	1.59	10.01	10.10	1.45
Sierra Leone 2013	9.56	9.80	1.60	9.62	9.90	1.62
Swaziland 2006-07	11.13	11.20	1.55	11.24	11.40	1.50
Tanzania 2010	10.46	10.50	1.45	10.60	10.70	1.41
Tanzania 2015-16	10.53	10.60	1.50	10.66	10.80	1.44
Timor-Leste 2009-10	11.13	11.20	1.21	11.16	11.20	1.24
Togo 2013-14	10.03	10.10	1.52	10.16	10.20	1.50
Uganda 2011	10.86	10.90	1.57	10.91	11.00	1.67
Uganda 2014-15	10.64	10.80	1.62	10.77	10.90	1.57
Yemen 2013	8.72	8.70	1.81	8.72	8.70	1.78
Zimbabwe 2010-11	10.58	10.70	1.47	10.68	10.80	1.40
Zimbabwe 2015	11.25	11.30	1.35	11.34	11.40	1.30

Note: Congo DR, Congo Democratic Republic; ST, Sao Tome; SD, Standard deviation; Hemoglobin adjusted for altitude prior to removing implausible values

Table A.5.3 Mean, standard deviation, and median hemoglobin concentrations g/dL for children after removing values outside the range 4-18 g/dL, by wealth quintile

	Lowest			Second			Middle			Fourth			Highest		
	Mean	Median	SD	Mean	Median	SD	Mean	Median	SD	Mean	Median	SD	Mean	Median	SD
Albania 2008-09	11.65	11.80	1.17	11.68	11.90	1.21	11.79	12.00	1.24	11.86	12.10	1.09	12.18	12.30	0.89
Angola 2011	10.78	11.00	1.55	10.75	10.80	1.51	10.67	10.80	1.37	10.63	10.60	1.31	10.91	11.00	1.25
Angola 2015-16	10.31	10.40	1.49	10.36	10.50	1.52	10.37	10.40	1.33	10.52	10.60	1.30	10.61	10.70	1.27
Armenia 2005	11.51	11.80	1.65	11.66	11.90	1.43	11.72	11.90	1.44	11.46	11.60	1.56	11.19	11.50	1.76
Azerbaijan 2006	11.14	11.20	1.34	11.22	11.30	1.28	11.24	11.30	1.22	11.42	11.50	1.28	11.54	11.80	1.12
Bangladesh 2011	10.62	10.70	1.19	10.62	10.70	1.22	10.85	10.90	1.25	10.94	11.10	1.12	10.99	11.10	1.33
Benin 2006	9.40	9.50	1.71	9.48	9.70	1.73	9.44	9.50	1.68	9.80	10.00	1.61	10.34	10.50	1.51
Benin 2011-12	10.28	10.40	1.62	10.38	10.50	1.56	10.42	10.50	1.52	10.67	10.80	1.53	10.88	11.00	1.48
Bolivia 2003	10.67	10.80	1.46	10.73	10.90	1.45	10.84	11.10	1.57	10.99	11.20	1.75	11.33	11.30	1.53
Bolivia 2008	10.37	10.40	1.50	10.48	10.60	1.52	10.33	10.40	1.70	10.66	10.80	1.65	10.93	11.10	1.60
Burkina Faso 2010	8.82	8.90	1.71	8.92	9.00	1.61	8.85	8.90	1.66	9.08	9.10	1.59	9.64	9.70	1.60
Burkina Faso 2014	8.69	8.70	1.75	8.91	9.00	1.76	9.06	9.10	1.71	9.09	9.10	1.66	9.77	9.90	1.67
Burundi 2010	10.84	11.00	1.38	10.99	11.20	1.41	10.96	11.10	1.37	11.03	11.20	1.33	11.27	11.40	1.28
Burundi 2012	10.42	10.60	1.67	10.65	10.80	1.59	10.84	11.10	1.53	10.86	11.10	1.60	11.17	11.30	1.34
Cambodia 2010	10.50	10.60	1.34	10.60	10.70	1.33	10.69	10.80	1.31	10.85	10.90	1.34	11.09	11.20	1.26
Cambodia 2014	10.42	10.50	1.30	10.59	10.60	1.23	10.70	10.80	1.27	10.81	10.80	1.25	11.10	11.20	1.23
Cameroon 2004	9.87	10.00	1.72	9.94	10.10	1.77	9.97	10.10	1.77	10.28	10.30	1.70	10.56	10.70	1.53
Cameroon 2011	10.21	10.20	1.47	10.40	10.50	1.59	10.36	10.50	1.55	10.51	10.60	1.50	10.79	10.90	1.37
Congo 2005	10.18	10.30	1.56	10.28	10.30	1.41	10.22	10.30	1.50	10.43	10.50	1.41	10.74	10.70	1.40
Congo 2011-12	10.37	10.50	1.35	10.31	10.40	1.37	10.42	10.50	1.34	10.43	10.50	1.20	10.57	10.70	1.25
Congo DR 2007	9.91	9.90	1.73	9.81	9.80	1.66	10.09	10.10	1.70	10.31	10.40	1.70	10.39	10.40	1.45
Congo DR 2013-14	10.13	10.30	1.70	10.15	10.40	1.78	10.27	10.30	1.68	10.42	10.50	1.69	10.77	10.90	1.46
Cote d'Ivoire 2011-12	9.68	9.70	1.51	9.61	9.70	1.51	9.86	10.00	1.49	10.11	10.20	1.60	10.45	10.60	1.51
Egypt 2014	11.27	11.30	1.26	11.33	11.40	1.22	11.51	11.60	1.13	11.49	11.50	1.13	11.61	11.60	1.10
Ethiopia 2011	10.42	10.60	1.85	10.76	10.90	1.75	10.88	11.10	1.75	10.91	11.10	1.67	11.03	11.20	1.69
Ethiopia 2016	9.92	10.10	1.80	10.44	10.60	1.68	10.75	10.90	1.59	10.65	10.80	1.67	10.78	10.90	1.55
Gabon 2012	10.28	10.40	1.46	10.35	10.50	1.42	10.57	10.70	1.21	10.59	10.70	1.31	10.81	10.90	1.23
Gambia 2013	9.61	9.70	1.57	9.75	9.90	1.49	9.62	9.80	1.66	10.02	10.20	1.52	10.46	10.60	1.51
Ghana 2014	9.71	9.80	1.54	9.89	10.10	1.55	10.21	10.30	1.52	10.54	10.60	1.37	11.10	11.10	1.24
Ghana 2016	9.84	10.00	1.51	10.06	10.30	1.58	10.42	10.60	1.42	10.67	10.80	1.36	10.93	10.90	1.09
Guatemala 2014-15	11.23	11.30	1.34	11.36	11.40	1.29	11.36	11.40	1.32	11.56	11.60	1.29	11.80	11.80	1.22
Guinea 2005	9.66	9.70	1.56	9.64	9.80	1.67	9.74	9.80	1.71	9.89	10.00	1.69	10.08	10.20	1.52
Guinea 2012	9.35	9.40	1.81	9.51	9.60	1.70	9.65	9.80	1.70	10.04	10.20	1.72	10.31	10.40	1.37
Guyana 2009	11.23	11.30	1.33	11.11	11.30	1.32	11.09	11.20	1.42	11.27	11.40	1.42	11.44	11.40	1.18
Haiti 2005-06	10.54	10.70	1.61	10.59	10.70	1.50	10.50	10.70	1.51	10.13	10.20	1.63	10.58	10.70	1.46
Haiti 2012	10.49	10.50	1.29	10.44	10.50	1.32	10.18	10.20	1.27	10.36	10.40	1.32	10.71	10.80	1.38
Honduras 2005-06	11.23	11.30	1.28	11.19	11.30	1.34	11.22	11.30	1.33	11.45	11.50	1.23	11.64	11.70	1.19
Honduras 2011-12	11.41	11.50	1.29	11.49	11.60	1.23	11.47	11.50	1.25	11.60	11.60	1.19	11.71	11.70	1.12
India 2005-06	9.95	10.10	1.47	10.07	10.20	1.55	10.26	10.40	1.56	10.40	10.50	1.57	10.70	10.90	1.54
Jordan 2009	11.18	11.30	1.42	11.43	11.60	1.35	11.50	11.60	1.35	11.62	11.70	1.26	11.86	12.10	1.24
Jordan 2012	11.31	11.40	1.45	11.54	11.60	1.32	11.57	11.60	1.37	11.65	11.70	1.35	11.82	12.00	1.29
Kenya 2015	10.97	11.10	1.54	11.13	11.30	1.55	11.28	11.30	1.45	11.51	11.60	1.35	11.72	11.80	1.42
Kyrgyz Republic 2012	10.93	11.10	1.53	10.96	11.20	1.50	11.08	11.30	1.55	11.05	11.10	1.42	11.16	11.30	1.46
Lesotho 2009	10.90	11.00	1.50	10.89	11.00	1.38	10.95	11.10	1.45	10.99	11.10	1.49	10.98	11.20	1.65
Lesotho 2014	10.81	10.80	1.56	10.88	10.90	1.63	10.92	10.90	1.68	10.94	11.10	1.63	11.16	11.20	1.55

Liberia 2011	9.99	10.10	1.53	9.86	9.80	1.48	9.75	9.80	1.51	10.11	10.20	1.38	10.26	10.40	1.44
Madagascar 2013	10.78	10.80	1.49	10.88	10.90	1.40	10.97	11.00	1.41	10.99	11.10	1.57	11.02	11.20	1.46
Madagascar 2016	10.98	11.10	1.38	11.12	11.20	1.36	11.22	11.30	1.39	11.10	11.10	1.45	10.96	11.10	1.48
Malawi 2014	10.41	10.60	1.61	10.61	10.80	1.51	10.78	11.00	1.46	10.89	10.90	1.47	10.95	11.10	1.42
Malawi 2015-16	10.18	10.20	1.51	10.27	10.40	1.53	10.48	10.60	1.44	10.46	10.50	1.41	10.68	10.80	1.41
Mali 2012-13	9.05	9.20	1.77	9.10	9.20	1.72	9.23	9.20	1.69	9.53	9.60	1.64	10.26	10.40	1.57
Mali 2015	8.94	9.00	1.66	9.02	9.10	1.66	9.15	9.20	1.66	9.49	9.60	1.54	10.03	10.20	1.41
Moldova 2005	11.18	11.30	1.21	11.31	11.30	1.15	11.41	11.50	1.13	11.45	11.50	1.19	11.61	11.60	1.09
Mozambique 2011	9.69	9.80	1.63	9.93	10.00	1.60	10.23	10.30	1.56	10.45	10.50	1.49	10.83	10.90	1.42
Myanmar 2015-16	10.62	10.70	1.34	10.71	10.90	1.39	10.74	10.80	1.41	10.83	10.90	1.31	10.83	10.90	1.30
Namibia 2013	10.81	10.80	1.44	10.85	10.90	1.35	10.89	11.00	1.42	10.93	11.10	1.50	11.19	11.30	1.43
Nepal 2006	11.01	11.10	1.43	10.85	10.90	1.35	10.79	10.90	1.33	10.96	11.10	1.35	11.18	11.30	1.34
Nepal 2011	11.03	11.10	1.32	10.89	11.00	1.37	10.93	11.00	1.38	11.01	11.10	1.36	11.34	11.30	1.30
Niger 2006	9.21	9.20	1.76	9.24	9.30	1.59	9.42	9.50	1.85	9.52	9.50	1.81	9.77	9.90	1.60
Niger 2012	9.79	9.90	1.48	9.93	10.00	1.51	9.98	10.10	1.43	9.87	10.00	1.47	10.00	10.00	1.59
Nigeria 2015	9.49	9.60	1.71	9.74	9.80	1.64	10.09	10.20	1.55	10.42	10.50	1.44	10.92	11.00	1.28
Peru 2011	11.25	11.30	1.29	11.26	11.40	1.33	11.41	11.50	1.31	11.63	11.70	1.26	11.92	12.00	1.17
Peru 2012	11.14	11.20	1.24	11.19	11.30	1.24	11.33	11.50	1.31	11.64	11.70	1.21	11.83	11.90	1.15
Rwanda 2010	11.25	11.20	1.42	11.27	11.30	1.27	11.37	11.40	1.32	11.33	11.40	1.30	11.36	11.50	1.44
Rwanda 2014-15	11.06	11.20	1.51	11.22	11.40	1.43	11.25	11.40	1.37	11.42	11.40	1.26	11.55	11.60	1.26
ST and Principe 2008-09	10.49	10.50	1.21	10.51	10.60	1.32	10.65	10.80	1.31	10.79	10.90	1.27	10.76	10.80	1.20
Senegal 2014	10.13	10.20	1.64	10.41	10.50	1.55	10.74	10.80	1.48	10.94	11.00	1.38	10.84	10.90	1.50
Senegal 2015	9.72	9.80	1.59	9.93	10.10	1.53	10.28	10.40	1.36	10.50	10.60	1.31	10.78	10.90	1.29
Sierra Leone 2008	9.86	10.00	1.51	9.80	10.00	1.56	9.80	9.90	1.48	9.92	10.10	1.57	10.37	10.30	1.42
Sierra Leone 2013	9.54	9.80	1.62	9.47	9.80	1.58	9.46	9.70	1.54	9.61	9.80	1.59	9.97	10.20	1.70
Swaziland 2006-07	11.12	11.20	1.57	11.33	11.40	1.55	11.11	11.20	1.51	11.14	11.20	1.46	11.21	11.40	1.52
Tanzania 2010	10.43	10.50	1.52	10.48	10.50	1.41	10.63	10.70	1.41	10.55	10.60	1.39	10.54	10.60	1.41
Tanzania 2015-16	10.44	10.60	1.52	10.47	10.60	1.56	10.63	10.70	1.42	10.70	10.70	1.42	10.81	10.90	1.38
Timor-Leste 2009-10	11.07	11.20	1.21	11.26	11.30	1.14	11.12	11.20	1.22	11.13	11.30	1.28	11.14	11.20	1.31
Togo 2013-14	10.03	10.10	1.61	9.86	10.00	1.56	10.01	10.00	1.49	10.25	10.30	1.30	10.58	10.70	1.32
Uganda 2011	10.60	10.70	1.68	10.78	10.90	1.61	10.90	11.00	1.61	11.00	11.10	1.65	11.26	11.40	1.43
Uganda 2014-15	10.56	10.70	1.61	10.57	10.80	1.59	10.66	10.80	1.62	10.96	11.10	1.55	11.02	11.10	1.53
Yemen 2013	8.37	8.30	1.69	8.56	8.50	1.68	8.67	8.60	1.88	8.90	8.80	1.77	9.40	9.40	1.84
Zimbabwe 2010-11	10.63	10.70	1.48	10.60	10.60	1.40	10.66	10.80	1.43	10.59	10.70	1.50	10.69	10.80	1.30
Zimbabwe 2015	11.26	11.30	1.33	11.33	11.40	1.31	11.28	11.30	1.21	11.24	11.30	1.36	11.37	11.50	1.42

Note: Congo DR, Congo Democratic Republic; ST, Sao Tome; SD, Standard deviation; Hemoglobin adjusted for altitude prior to removing implausible values

Table A.5.4 Mean, standard deviation, and median hemoglobin concentrations g/dL for children after removing values outside the range 4-18 g/dL, by residence

	Urban			Rural		
	Mean	Median	SD	Mean	Median	SD
Albania 2008-09	11.95	12.10	1.01	11.70	11.90	1.23
Angola 2011	10.70	10.80	1.32	10.76	10.90	1.48
Angola 2015-16	10.43	10.50	1.37	10.35	10.40	1.48
Armenia 2005	11.52	11.80	1.59	11.56	11.70	1.52
Azerbaijan 2006	11.37	11.50	1.25	11.19	11.30	1.28
Bangladesh 2011	10.86	11.00	1.29	10.77	10.90	1.21
Benin 2006	9.95	10.10	1.64	9.48	9.60	1.70
Benin 2011-12	10.63	10.70	1.54	10.42	10.50	1.57
Bolivia 2003	10.93	11.10	1.63	10.75	10.80	1.47
Bolivia 2008	10.59	10.80	1.65	10.42	10.50	1.53
Burkina Faso 2010	9.49	9.60	1.61	8.91	9.00	1.65
Burkina Faso 2014	9.55	9.60	1.62	8.93	8.90	1.74
Burundi 2010	11.21	11.30	1.34	10.99	11.10	1.36
Burundi 2012	11.23	11.30	1.30	10.70	10.90	1.60
Cambodia 2010	11.02	11.20	1.32	10.64	10.70	1.32
Cambodia 2014	10.97	11.10	1.27	10.63	10.70	1.27
Cameroon 2004	10.34	10.40	1.62	9.92	10.00	1.77
Cameroon 2011	10.63	10.70	1.43	10.30	10.30	1.56
Congo 2005	10.37	10.50	1.46	10.31	10.30	1.50
Congo 2011-12	10.37	10.40	1.28	10.38	10.50	1.35
Congo DR 2007	10.27	10.40	1.53	9.97	10.00	1.76
Congo DR 2013-14	10.41	10.50	1.63	10.25	10.40	1.72
Cote d'Ivoire 2011-12	10.20	10.40	1.55	9.70	9.70	1.51
Egypt 2014	11.55	11.60	1.10	11.38	11.50	1.21
Ethiopia 2011	10.98	11.20	1.74	10.70	10.90	1.78
Ethiopia 2016	10.66	10.80	1.64	10.32	10.50	1.74
Gabon 2012	10.46	10.60	1.38	10.33	10.40	1.42
Gambia 2013	10.18	10.30	1.50	9.64	9.80	1.58
Ghana 2014	10.48	10.60	1.47	9.89	10.00	1.55
Ghana 2016	10.60	10.70	1.33	10.03	10.20	1.55
Guatemala 2014-15	11.56	11.60	1.29	11.34	11.40	1.32
Guinea 2005	10.05	10.10	1.60	9.70	9.80	1.64
Guinea 2012	10.23	10.30	1.50	9.52	9.60	1.77
Guyana 2009	11.17	11.30	1.42	11.22	11.30	1.33
Haiti 2005-06	10.30	10.40	1.55	10.56	10.70	1.56
Haiti 2012	10.33	10.40	1.36	10.45	10.50	1.30
Honduras 2005-06	11.42	11.50	1.27	11.23	11.30	1.30
Honduras 2011-12	11.53	11.60	1.21	11.48	11.60	1.25
India 2005-06	10.44	10.50	1.59	10.20	10.30	1.54
Jordan 2009	11.44	11.60	1.35	11.35	11.40	1.41
Jordan 2012	11.53	11.60	1.37	11.51	11.60	1.39
Kenya 2015	11.37	11.50	1.46	11.15	11.30	1.53
Kyrgyz Republic 2012	11.06	11.10	1.46	11.01	11.20	1.51
Lesotho 2009	10.75	10.90	1.65	10.95	11.00	1.45
Lesotho 2014	10.95	11.00	1.59	10.90	10.90	1.62
Liberia 2011	9.92	10.00	1.45	9.96	10.00	1.51
Madagascar 2013	10.86	11.00	1.50	10.92	11.00	1.46
Madagascar 2016	10.88	11.00	1.46	11.11	11.20	1.40
Malawi 2014	10.88	11.00	1.40	10.67	10.80	1.54
Malawi 2015-16	10.64	10.70	1.45	10.36	10.50	1.47
Mali 2012-13	10.19	10.30	1.54	9.19	9.30	1.73
Mali 2015	9.97	10.10	1.43	9.11	9.20	1.65
Moldova 2005	11.50	11.50	1.16	11.32	11.40	1.15
Mozambique 2011	10.57	10.60	1.51	10.10	10.20	1.60
Myanmar 2015-16	10.77	10.80	1.32	10.71	10.80	1.37
Namibia 2013	10.90	11.00	1.46	10.91	11.00	1.42
Nepal 2006	11.10	11.20	1.37	10.91	11.00	1.37
Nepal 2011	11.08	11.10	1.37	11.01	11.10	1.35
Niger 2006	9.74	9.90	1.66	9.36	9.40	1.74
Niger 2012	10.02	10.00	1.57	9.89	10.00	1.48
Nigeria 2015	10.62	10.80	1.48	9.87	10.00	1.62
Peru 2011	11.50	11.60	1.29	11.24	11.40	1.31
Peru 2012	11.43	11.60	1.26	11.17	11.20	1.26
Rwanda 2010	11.39	11.50	1.45	11.30	11.30	1.33
Rwanda 2014-15	11.47	11.50	1.27	11.23	11.40	1.42

ST and Principe 2008-09	10.49	10.60	1.26	10.70	10.80	1.27
Senegal 2014	10.79	10.90	1.46	10.33	10.40	1.61
Senegal 2015	10.42	10.50	1.37	9.95	10.10	1.54
Sierra Leone 2008	10.13	10.20	1.54	9.84	10.00	1.51
Sierra Leone 2013	9.74	10.00	1.70	9.52	9.80	1.56
Swaziland 2006-07	10.96	11.00	1.49	11.23	11.40	1.53
Tanzania 2010	10.54	10.60	1.38	10.52	10.60	1.44
Tanzania 2015-16	10.75	10.80	1.41	10.55	10.60	1.49
Timor-Leste 2009-10	11.21	11.30	1.28	11.13	11.20	1.21
Togo 2013-14	10.41	10.50	1.33	9.98	10.10	1.56
Uganda 2011	11.15	11.30	1.43	10.82	10.90	1.66
Uganda 2014-15	11.03	11.10	1.57	10.65	10.80	1.59
Yemen 2013	9.07	9.00	1.77	8.61	8.60	1.79
Zimbabwe 2010-11	10.53	10.70	1.46	10.66	10.70	1.42
Zimbabwe 2015	11.31	11.40	1.41	11.29	11.30	1.29

Note: Congo DR, Congo Democratic Republic; ST, Sao Tome; SD, Standard deviation; Hemoglobin adjusted for altitude prior to removing implausible values

Table A.5.5 Mean, standard deviation, and median hemoglobin concentrations g/dL for nonpregnant women after removing values outside the range 4-18 g/dL, by age

	15-19			20-24			35-49		
	Mean	Median	SD	Mean	Median	SD	Mean	Median	SD
Albania 2008-09	12.83	12.80	1.11	12.85	12.90	1.15	12.80	12.90	1.30
Armenia 2005	13.01	13.10	1.40	12.94	13.00	1.34	12.72	12.90	1.58
Azerbaijan 2006	12.52	12.60	1.37	12.28	12.40	1.47	12.13	12.40	1.69
Bangladesh 2011	12.16	12.20	1.28	12.24	12.30	1.35	12.08	12.20	1.38
Benin 2006	11.53	11.60	1.53	11.46	11.50	1.58	11.39	11.50	1.64
Benin 2011-12	12.18	12.30	1.48	12.21	12.30	1.52	12.20	12.30	1.56
Bolivia 2003	12.63	12.70	1.43	12.55	12.70	1.59	12.52	12.70	1.68
Bolivia 2008	12.43	12.50	1.63	12.31	12.50	1.59	12.34	12.40	1.68
Burkina Faso 2010	11.86	12.10	1.74	11.90	12.10	1.74	11.90	12.10	1.77
Burundi 2010	13.36	13.40	1.42	13.27	13.40	1.53	13.21	13.30	1.54
Cambodia 2010	12.00	12.10	1.32	12.19	12.30	1.37	12.03	12.20	1.53
Cambodia 2014	11.97	12.10	1.31	12.14	12.20	1.28	12.02	12.10	1.43
Cameroon 2004	12.14	12.20	1.63	12.08	12.20	1.74	12.04	12.20	1.79
Cameroon 2011	12.22	12.40	1.63	12.26	12.40	1.58	12.22	12.40	1.70
Congo 2005	11.66	11.70	1.44	11.57	11.70	1.50	11.48	11.60	1.53
Congo 2011-12	11.80	11.90	1.36	11.82	11.90	1.41	11.74	11.80	1.43
Congo DR 2007	12.01	12.10	1.74	11.86	11.90	1.78	11.79	11.90	1.78
Congo DR 2013-14	12.23	12.30	1.53	12.24	12.30	1.57	12.25	12.30	1.62
Cote d'Ivoire 2011-12	11.82	11.90	1.54	11.70	11.80	1.63	11.75	11.90	1.66
Egypt 2014	12.50	12.50	1.00	12.57	12.60	1.09	12.59	12.60	1.17
Ethiopia 2011	13.37	13.50	1.69	13.15	13.40	1.77	13.03	13.20	1.68
Ethiopia 2016	12.92	13.10	1.69	12.73	13.00	1.84	12.75	12.90	1.71
Gabon 2012	11.43	11.60	1.54	11.54	11.60	1.55	11.46	11.70	1.67
Gambia 2013	11.50	11.70	1.61	11.29	11.40	1.75	11.26	11.50	1.78
Ghana 2014	11.85	12.00	1.36	12.12	12.30	1.49	12.21	12.30	1.52
Guatemala 2014-15	13.37	13.40	1.30	13.34	13.40	1.37	13.22	13.40	1.54
Guinea 2005	11.78	12.00	1.82	11.73	11.80	1.68	11.83	12.00	1.69
Guinea 2012	11.91	12.10	1.55	11.91	12.00	1.58	11.78	12.00	1.69
Guyana 2009	12.30	12.50	1.49	12.41	12.50	1.47	12.18	12.40	1.70
Haiti 2005-06	11.91	12.20	1.85	12.01	12.20	1.80	12.05	12.30	1.88
Haiti 2012	11.68	11.80	1.56	11.91	12.10	1.58	11.95	12.10	1.64
Honduras 2005-06	13.14	13.20	1.33	13.14	13.20	1.37	13.02	13.10	1.49
Honduras 2011-12	13.24	13.30	1.25	13.27	13.30	1.32	13.09	13.20	1.47
India 2005-06	11.66	11.90	1.69	11.69	11.90	1.71	11.70	11.90	1.77
Jordan 2009	12.94	13.00	1.36	12.77	12.90	1.42	12.49	12.70	1.59
Jordan 2012	12.67	12.80	1.50	12.51	12.60	1.48	12.13	12.30	1.72
Kyrgyz Republic 2012	12.38	12.50	1.48	12.19	12.40	1.58	12.42	12.70	1.81
Lesotho 2009	13.07	13.20	1.53	12.74	13.00	1.80	12.91	13.10	1.75
Lesotho 2014	12.85	13.00	1.79	12.85	13.00	1.77	12.91	13.10	1.87
Malawi 2015-16	12.45	12.50	1.52	12.59	12.70	1.64	12.36	12.50	1.75
Mali 2012-13	11.87	12.00	1.57	11.78	12.00	1.61	11.72	11.80	1.67
Moldova 2005	12.70	12.80	1.22	12.61	12.70	1.33	12.50	12.60	1.45
Mozambique 2011	11.73	11.80	1.72	11.71	11.80	1.76	11.72	11.90	1.75
Myanmar 2015-16	11.99	12.10	1.42	12.13	12.20	1.45	11.98	12.10	1.62
Namibia 2013	13.12	13.30	1.56	13.17	13.30	1.56	12.96	13.10	1.66
Nepal 2006	12.33	12.50	1.45	12.45	12.60	1.56	12.57	12.70	1.61
Nepal 2011	12.46	12.60	1.45	12.61	12.70	1.52	12.59	12.70	1.60
Niger 2006	12.08	12.20	1.82	12.21	12.30	1.87	12.09	12.20	1.89
Niger 2012	12.04	12.20	1.57	12.14	12.30	1.63	11.96	12.10	1.56
Peru 2011	13.05	13.20	1.26	13.08	13.20	1.33	13.02	13.20	1.45
Peru 2012	12.99	13.10	1.20	13.00	13.10	1.30	12.96	13.10	1.42
Rwanda 2010	13.33	13.50	1.46	13.37	13.50	1.52	13.20	13.40	1.60
Rwanda 2014-15	13.06	13.10	1.36	13.12	13.20	1.49	13.10	13.20	1.60
ST and Principe 2008-09	11.79	11.90	1.45	12.13	12.20	1.50	12.34	12.40	1.54
Sierra Leone 2008	11.80	11.90	1.62	12.01	12.20	1.60	11.99	12.20	1.71
Sierra Leone 2013	11.90	12.00	1.55	12.05	12.10	1.58	12.05	12.20	1.60
Swaziland 2006-07	12.68	12.80	1.58	12.60	12.70	1.72	12.71	12.90	1.74
Tanzania 2010	12.09	12.20	1.56	12.14	12.30	1.75	12.09	12.30	1.81
Tanzania 2015-16	11.95	12.10	1.59	12.05	12.20	1.67	11.93	12.10	1.74
Timor-Leste 2009-10	12.70	12.80	1.30	12.84	13.00	1.39	12.79	13.00	1.50
Togo 2013-14	11.79	11.90	1.56	12.11	12.20	1.52	12.14	12.30	1.70
Uganda 2011	13.06	13.20	1.63	13.08	13.20	1.65	12.81	13.00	1.71
Yemen 2013	10.74	10.70	1.80	10.68	10.80	1.88	10.63	10.70	1.96
Zimbabwe 2010-11	12.77	13.00	1.73	12.76	13.00	1.83	12.61	12.90	1.91
Zimbabwe 2015	12.75	12.90	1.62	12.81	13.00	1.71	12.63	12.80	1.80

Note: Congo DR, Congo Democratic Republic; ST, Sao Tome; SD, Standard deviation; Hemoglobin adjusted for altitude and smoking prior to removing implausible values

Table A.5.6 Mean, standard deviation, and median hemoglobin concentrations g/dL for nonpregnant women after removing values outside the range 4-18 g/dL, wealth quintile

	Lowest			Second			Middle			Fourth			Highest		
	Mean	Median	SD	Mean	Median	SD	Mean	Median	SD	Mean	Median	SD	Mean	Median	SD
Albania 2008-09	12.74	12.80	1.24	12.79	12.90	1.34	12.82	12.90	1.27	12.89	12.90	1.19	12.87	12.80	1.02
Armenia 2005	12.83	12.90	1.43	12.87	12.90	1.52	12.88	13.00	1.47	12.90	13.10	1.45	12.79	12.90	1.43
Azerbaijan 2006	12.08	12.30	1.65	12.21	12.40	1.61	12.32	12.50	1.55	12.34	12.50	1.54	12.35	12.50	1.35
Bangladesh 2011	11.99	12.00	1.39	12.03	12.10	1.36	12.12	12.20	1.29	12.22	12.20	1.31	12.43	12.50	1.37
Benin 2006	11.45	11.60	1.63	11.48	11.60	1.53	11.43	11.50	1.62	11.42	11.50	1.63	11.47	11.60	1.54
Benin 2011-12	12.20	12.30	1.48	12.25	12.40	1.59	12.21	12.30	1.58	12.22	12.40	1.51	12.12	12.20	1.47
Bolivia 2003	12.18	12.30	1.54	12.29	12.40	1.54	12.47	12.50	1.59	12.77	12.90	1.59	12.90	13.00	1.54
Bolivia 2008	12.03	12.20	1.58	12.28	12.40	1.64	12.32	12.40	1.61	12.41	12.50	1.65	12.57	12.70	1.62
Burkina Faso 2010	11.65	11.80	1.82	11.77	11.90	1.76	11.83	12.00	1.79	12.00	12.20	1.67	12.10	12.30	1.68
Burundi 2010	13.12	13.20	1.51	13.12	13.20	1.51	13.19	13.30	1.48	13.34	13.40	1.38	13.50	13.60	1.55
Cambodia 2010	11.79	11.90	1.53	11.93	12.00	1.52	11.99	12.10	1.43	12.17	12.30	1.36	12.38	12.50	1.26
Cambodia 2014	11.80	11.90	1.43	11.96	12.00	1.33	12.03	12.10	1.31	12.18	12.20	1.33	12.25	12.30	1.26
Cameroon 2004	12.26	12.30	1.80	12.06	12.20	1.78	12.14	12.30	1.71	12.05	12.20	1.68	11.96	12.10	1.68
Cameroon 2011	12.38	12.50	1.61	12.35	12.50	1.70	12.25	12.40	1.64	12.19	12.30	1.61	12.10	12.20	1.57
Congo 2005	11.52	11.70	1.41	11.51	11.60	1.48	11.49	11.60	1.58	11.45	11.60	1.53	11.81	12.00	1.44
Congo 2011-12	11.90	12.00	1.43	11.76	11.90	1.48	11.70	11.80	1.35	11.73	11.70	1.35	11.67	11.80	1.24
Congo DR 2007	11.88	12.00	1.80	11.78	11.80	1.78	11.82	11.90	1.84	12.15	12.20	1.82	11.74	11.80	1.62
Congo DR 2013-14	12.24	12.40	1.62	12.24	12.30	1.61	12.34	12.40	1.53	12.26	12.30	1.52	12.13	12.30	1.58
Cote d'Ivoire 2011-12	11.75	11.90	1.67	11.63	11.70	1.62	11.73	11.80	1.61	11.81	11.90	1.66	11.77	11.90	1.56
Egypt 2014	12.49	12.50	1.27	12.61	12.70	1.17	12.64	12.70	1.15	12.64	12.60	1.05	12.52	12.50	1.00
Ethiopia 2011	12.77	13.00	1.91	13.12	13.30	1.71	13.13	13.30	1.74	13.22	13.40	1.68	13.46	13.60	1.57
Ethiopia 2016	12.12	12.40	2.00	12.73	13.00	1.75	12.85	13.00	1.71	12.99	13.20	1.64	13.14	13.30	1.56
Gabon 2012	11.72	11.80	1.56	11.38	11.50	1.68	11.36	11.50	1.53	11.24	11.40	1.60	11.46	11.60	1.52
Gambia 2013	11.14	11.40	1.71	11.12	11.30	1.72	11.12	11.30	1.72	11.43	11.60	1.76	11.90	12.00	1.59
Ghana 2014	12.12	12.30	1.42	11.91	12.00	1.52	12.03	12.20	1.54	12.21	12.30	1.44	12.22	12.30	1.48
Guatemala 2014-15	13.19	13.30	1.48	13.34	13.50	1.47	13.33	13.40	1.41	13.30	13.40	1.37	13.37	13.50	1.33
Guinea 2005	11.70	11.80	1.63	11.66	11.80	1.78	11.71	11.80	1.82	12.01	12.10	1.62	11.78	12.00	1.71
Guinea 2012	11.65	11.80	1.74	11.59	11.80	1.65	11.84	12.00	1.62	12.10	12.30	1.55	12.08	12.20	1.45
Guyana 2009	12.52	12.70	1.59	12.19	12.30	1.62	12.16	12.30	1.59	12.14	12.30	1.55	12.40	12.50	1.45
Haiti 2005-06	12.14	12.30	1.76	12.22	12.40	1.79	11.94	12.20	1.89	11.84	12.10	1.84	11.90	12.10	1.86
Haiti 2012	12.20	12.30	1.51	11.96	12.10	1.61	11.68	11.90	1.62	11.77	11.90	1.62	11.74	11.90	1.57
Honduras 2005-06	13.09	13.20	1.41	13.19	13.30	1.45	13.13	13.20	1.40	13.05	13.10	1.39	13.05	13.10	1.31
Honduras 2011-12	13.28	13.40	1.36	13.36	13.40	1.37	13.21	13.30	1.35	13.08	13.10	1.35	13.07	13.20	1.32
India 2005-06	11.26	11.40	1.73	11.46	11.60	1.78	11.62	11.80	1.76	11.74	11.90	1.73	11.96	12.10	1.62
Jordan 2009	12.68	12.80	1.48	12.61	12.80	1.56	12.75	12.90	1.39	12.78	12.90	1.47	12.89	13.10	1.43
Jordan 2012	12.42	12.60	1.61	12.37	12.50	1.59	12.35	12.50	1.63	12.49	12.70	1.53	12.51	12.60	1.51
Kyrgyz Republic 2012	12.17	12.50	1.71	12.31	12.50	1.67	12.27	12.50	1.69	12.32	12.60	1.72	12.50	12.70	1.44
Lesotho 2009	12.98	13.20	1.61	12.96	13.10	1.60	12.83	12.90	1.68	12.77	13.00	1.80	12.81	13.10	1.92
Lesotho 2014	13.12	13.30	1.77	13.06	13.30	1.74	12.81	13.00	1.82	12.66	12.80	1.85	12.75	13.00	1.80
Malawi 2015-16	12.52	12.60	1.57	12.58	12.70	1.59	12.55	12.70	1.61	12.46	12.60	1.70	12.42	12.60	1.73
Mali 2012-13	11.51	11.60	1.66	11.67	11.80	1.59	11.70	11.80	1.57	11.74	11.90	1.69	12.10	12.20	1.56
Moldova 2005	12.42	12.50	1.41	12.43	12.60	1.34	12.48	12.60	1.42	12.64	12.70	1.31	12.74	12.80	1.34
Mozambique 2011	11.39	11.60	1.60	11.66	11.70	1.64	11.83	12.00	1.66	11.83	11.90	1.75	11.74	11.90	1.87
Myanmar 2015-16	11.93	12.00	1.59	12.01	12.10	1.57	12.06	12.20	1.50	12.12	12.20	1.50	12.08	12.20	1.46
Namibia 2013	12.84	13.00	1.68	13.08	13.20	1.55	13.11	13.20	1.62	13.11	13.20	1.66	13.22	13.30	1.49

Nepal 2006	12.64	12.80	1.59	12.25	12.40	1.56	12.33	12.50	1.59	12.49	12.60	1.50	12.53	12.60	1.50
Nepal 2011	12.61	12.70	1.54	12.55	12.60	1.58	12.45	12.60	1.53	12.52	12.60	1.46	12.68	12.80	1.54
Niger 2006	11.69	11.80	1.83	12.00	12.10	1.90	12.14	12.30	1.90	12.07	12.30	1.97	12.47	12.60	1.74
Niger 2012	11.74	12.00	1.73	12.08	12.20	1.55	11.97	12.00	1.60	12.19	12.30	1.55	12.22	12.30	1.56
Peru 2011	13.03	13.10	1.39	13.06	13.20	1.36	13.01	13.10	1.38	13.09	13.20	1.36	13.11	13.20	1.32
Peru 2012	12.87	12.90	1.38	12.98	13.10	1.32	13.02	13.10	1.31	13.03	13.10	1.32	13.01	13.10	1.32
Rwanda 2010	13.25	13.40	1.56	13.20	13.30	1.52	13.33	13.50	1.52	13.37	13.50	1.45	13.40	13.60	1.57
Rwanda 2014-15	12.81	13.00	1.56	13.06	13.20	1.48	13.18	13.30	1.47	13.23	13.30	1.40	13.19	13.30	1.51
ST and Principe 2008-09	12.12	12.10	1.53	12.08	12.20	1.52	12.01	12.20	1.57	12.18	12.20	1.48	12.25	12.20	1.47
Sierra Leone 2008	11.96	12.10	1.65	11.91	12.10	1.67	11.94	12.10	1.56	11.95	12.20	1.73	12.06	12.20	1.60
Sierra Leone 2013	11.84	11.90	1.51	11.88	12.00	1.57	11.82	12.00	1.56	12.01	12.10	1.55	12.39	12.50	1.61
Swaziland 2006-07	12.84	13.00	1.57	12.80	12.90	1.64	12.61	12.80	1.78	12.56	12.70	1.70	12.55	12.70	1.71
Tanzania 2010	12.14	12.30	1.74	12.16	12.30	1.72	12.28	12.40	1.70	12.12	12.20	1.73	11.92	12.10	1.73
Tanzania 2015-16	11.89	12.00	1.66	11.95	12.10	1.62	12.03	12.20	1.71	12.08	12.20	1.70	11.97	12.10	1.68
Timor-Leste 2009-10	12.80	13.00	1.47	12.84	13.00	1.39	12.86	13.00	1.33	12.74	12.90	1.40	12.69	12.80	1.43
Togo 2013-14	12.29	12.40	1.54	12.33	12.40	1.54	12.10	12.20	1.64	11.81	11.90	1.65	11.75	11.90	1.54
Uganda 2011	12.69	12.80	1.54	12.87	13.00	1.55	13.06	13.20	1.52	12.99	13.10	1.69	13.26	13.40	1.83
Yemen 2013	10.11	10.20	1.86	10.64	10.70	1.93	10.66	10.80	1.90	10.86	10.90	1.93	10.98	11.10	1.80
Zimbabwe 2010-11	12.78	13.00	1.85	12.78	13.00	1.83	12.79	13.00	1.80	12.66	12.90	1.85	12.63	12.80	1.83
Zimbabwe 2015	12.69	12.80	1.68	12.86	13.00	1.67	12.71	12.90	1.71	12.77	13.00	1.80	12.71	12.90	1.71

Note: Congo DR, Congo Democratic Republic; ST, Sao Tome; SD, Standard deviation; Hemoglobin adjusted for altitude and smoking prior to removing implausible values

Table A.5.7 Mean, standard deviation, and median adjusted-hemoglobin concentrations g/dL for nonpregnant women after removing values outside the range 4-18 g/dL, education

	No Education			Primary			Secondary			Higher		
	Mean	Median	SD	Mean	Median	SD	Mean	Median	SD	Mean	Median	SD
Albania 2008-09	12.36	12.40	1.49	12.80	12.90	1.26	12.83	12.90	1.22	12.90	12.90	0.91
Armenia 2005	11.94	11.90	1.91	13.00	13.20	1.50	12.84	12.90	1.48	12.93	13.10	1.41
Azerbaijan 2006	12.06	12.20	1.50	12.02	12.40	1.79	12.24	12.40	1.57	12.43	12.60	1.37
Bangladesh 2011	12.02	12.10	1.40	12.11	12.20	1.37	12.31	12.30	1.29	12.31	12.50	1.37
Benin 2006	11.44	11.50	1.60	11.48	11.60	1.60	11.45	11.50	1.52	11.73	11.90	1.90
Benin 2011-12	12.21	12.30	1.54	12.10	12.20	1.53	12.28	12.40	1.49	11.88	12.00	1.34
Bolivia 2003	12.22	12.40	1.75	12.47	12.60	1.59	12.62	12.70	1.54	12.89	13.00	1.57
Bolivia 2008	12.01	12.10	1.68	12.28	12.40	1.62	12.38	12.50	1.63	12.52	12.60	1.63
Burkina Faso 2010	11.82	12.00	1.77	12.10	12.20	1.61	12.07	12.30	1.73	12.16	12.50	1.52
Burundi 2010	13.17	13.30	1.50	13.27	13.40	1.49	13.61	13.70	1.47	13.30	13.80	1.88
Cambodia 2010	11.94	12.00	1.59	12.06	12.10	1.43	12.20	12.30	1.33	12.37	12.50	1.08
Cambodia 2014	11.99	12.10	1.49	12.02	12.10	1.36	12.14	12.20	1.26	12.23	12.30	1.18
Cameroon 2004	12.38	12.60	1.91	12.03	12.10	1.70	11.99	12.10	1.64	11.86	12.00	1.62
Cameroon 2011	12.23	12.40	1.74	12.35	12.40	1.61	12.13	12.20	1.61	12.42	12.50	1.38
Congo 2005	11.59	11.70	1.24	11.50	11.60	1.52	11.59	11.70	1.52	11.71	12.00	1.48
Congo 2011-12	11.93	12.00	1.35	11.80	11.90	1.44	11.77	11.80	1.39	11.73	11.70	1.36
Congo DR 2007	11.83	11.90	1.86	11.86	11.90	1.82	11.93	12.00	1.67	11.71	11.70	1.61
Congo DR 2013-14	12.37	12.40	1.61	12.23	12.30	1.59	12.19	12.30	1.55	12.34	12.50	1.59
Cote d'Ivoire 2011-12	11.69	11.80	1.63	11.73	11.80	1.64	11.89	12.00	1.56	11.81	12.00	1.61
Egypt 2014	12.57	12.60	1.18	12.68	12.70	1.20	12.56	12.60	1.12	12.58	12.60	0.99
Ethiopia 2011	12.90	13.10	1.84	13.40	13.50	1.60	13.59	13.70	1.45	13.56	13.60	1.47
Ethiopia 2016	12.46	12.70	1.91	12.94	13.10	1.66	13.13	13.30	1.58	13.24	13.40	1.46
Gabon 2012	11.80	11.90	1.55	11.58	11.70	1.58	11.42	11.60	1.59	11.23	11.60	1.63
Gambia 2013	11.13	11.30	1.75	11.30	11.50	1.66	11.60	11.70	1.70	11.76	11.80	1.65
Ghana 2014	12.10	12.30	1.46	12.09	12.20	1.42	12.07	12.20	1.52	12.39	12.40	1.42
Guatemala 2014-15	13.22	13.40	1.54	13.30	13.40	1.45	13.33	13.40	1.31	13.41	13.50	1.30
Guinea 2005	11.77	11.90	1.69	11.75	12.00	1.78	11.85	12.00	1.81	11.96	12.00	1.56
Guinea 2012	11.77	12.00	1.66	11.97	12.10	1.53	12.12	12.30	1.49	12.37	12.30	1.34
Guyana 2009	12.41	12.60	1.62	12.25	12.50	1.66	12.30	12.50	1.57	12.39	12.40	1.31
Haiti 2005-06	12.06	12.30	1.89	11.93	12.10	1.82	12.00	12.20	1.80	12.15	12.50	1.83
Haiti 2012	12.03	12.20	1.62	11.89	12.10	1.62	11.75	11.90	1.57	12.02	12.00	1.49
Honduras 2005-06	13.03	13.20	1.48	13.12	13.20	1.43	13.09	13.10	1.31	13.09	13.20	1.21
Honduras 2011-12	13.23	13.40	1.51	13.25	13.30	1.38	13.16	13.20	1.29	13.11	13.20	1.30
India 2005-06	11.47	11.60	1.79	11.60	11.80	1.75	11.80	12.00	1.68	12.05	12.20	1.57
Jordan 2009	12.56	12.70	1.68	12.57	12.70	1.55	12.71	12.80	1.47	12.80	12.90	1.42
Jordan 2012	12.34	12.50	1.74	12.37	12.50	1.73	12.38	12.50	1.57	12.49	12.70	1.56
Kyrgyz Republic 2012	11.74	12.00	2.14	12.54	12.50	1.50	12.33	12.60	1.64	12.29	12.50	1.66
Lesotho 2009	12.76	13.10	1.85	12.88	13.10	1.67	12.86	13.10	1.79	12.87	13.10	1.85
Lesotho 2014	12.94	13.00	1.27	12.93	13.10	1.80	12.82	13.00	1.82	12.81	13.00	1.80
Malawi 2015-16	12.36	12.50	1.68	12.53	12.70	1.63	12.49	12.60	1.67	12.39	12.40	1.70
Mali 2012-13	11.66	11.80	1.63	11.92	12.00	1.61	12.19	12.30	1.50	12.32	12.40	1.61
Moldova 2005	12.82	12.80	1.54	13.12	13.20	1.08	12.55	12.70	1.36	12.63	12.70	1.38
Mozambique 2011	11.62	11.70	1.69	11.72	11.90	1.72	11.79	11.90	1.87	12.06	12.30	1.68
Myanmar 2015-16	12.03	12.10	1.63	12.01	12.10	1.56	12.09	12.20	1.47	12.02	12.10	1.43
Namibia 2013	12.94	13.00	1.61	12.97	13.20	1.70	13.12	13.20	1.57	13.35	13.40	1.54
Nepal 2006	12.38	12.50	1.61	12.58	12.70	1.54	12.51	12.60	1.45	12.63	12.70	1.44
Nepal 2011	12.51	12.60	1.58	12.65	12.70	1.55	12.57	12.70	1.48	12.68	12.80	1.50
Niger 2006	12.06	12.20	1.91	12.45	12.60	1.65	12.45	12.50	1.68	12.42	12.40	1.87
Niger 2012	12.04	12.20	1.61	12.11	12.20	1.62	12.21	12.40	1.47	12.26	12.00	1.40
Peru 2011	13.07	13.20	1.42	13.02	13.20	1.43	13.05	13.20	1.32	13.09	13.20	1.36
Peru 2012	12.84	13.00	1.48	12.97	13.10	1.39	12.96	13.00	1.29	13.05	13.20	1.32
Rwanda 2010	13.09	13.20	1.58	13.34	13.50	1.50	13.41	13.60	1.56	13.34	13.70	1.60
Rwanda 2014-15	12.97	13.10	1.65	13.12	13.20	1.49	13.14	13.20	1.40	12.93	13.20	1.71
ST and Principe 2008-09	11.87	11.90	1.51	12.19	12.20	1.51	12.07	12.20	1.52	11.67	11.60	1.38
Sierra Leone 2008	11.96	12.10	1.63	11.95	12.20	1.70	11.98	12.10	1.64	12.22	12.50	1.57
Sierra Leone 2013	11.94	12.00	1.56	11.91	12.00	1.59	12.14	12.30	1.57	12.71	12.80	1.67
Swaziland 2006-07	12.63	12.80	1.66	12.68	12.90	1.73	12.62	12.70	1.68	12.76	12.90	1.67
Tanzania 2010	11.93	12.10	1.78	12.26	12.40	1.73	11.89	12.00	1.64	11.99	12.10	1.44
Tanzania 2015-16	11.75	11.90	1.70	12.06	12.20	1.70	11.98	12.10	1.63	12.25	12.20	1.47
Timor-Leste 2009-10	12.75	13.00	1.49	12.84	13.00	1.44	12.78	12.90	1.34	12.90	13.00	1.07
Togo 2013-14	12.13	12.20	1.62	12.11	12.30	1.60	11.93	12.00	1.56	11.86	11.90	1.62
Uganda 2011	12.76	12.90	1.68	12.97	13.10	1.63	13.20	13.30	1.59	13.06	13.30	2.12
Yemen 2013	NA											
Zimbabwe 2010-11	12.82	13.10	1.92	12.75	13.00	1.89	12.72	12.90	1.81	12.60	12.90	1.76
Zimbabwe 2015	12.87	13.00	1.63	12.69	12.80	1.76	12.76	12.90	1.71	12.72	12.90	1.72

Note: Congo DR, Congo Democratic Republic; NA, not available; ST, Sao Tome; SD, Standard deviation; Hemoglobin adjusted for altitude and smoking prior to removing implausible values

Table A.5.8 Mean, standard deviation, and median hemoglobin concentrations g/dL for nonpregnant women after removing values outside the range 4-18 g/dL, residence

	Urban			Rural		
	Mean	Median	SD	Mean	Median	SD
Albania 2008-09	12.87	12.90	1.13	12.78	12.80	1.29
Armenia 2005	12.82	12.90	1.46	12.93	13.00	1.46
Azerbaijan 2006	12.31	12.50	1.51	12.19	12.40	1.60
Bangladesh 2011	12.31	12.30	1.36	12.10	12.20	1.34
Benin 2006	11.46	11.50	1.59	11.44	11.50	1.59
Benin 2011-12	12.18	12.30	1.48	12.22	12.40	1.56
Bolivia 2003	12.67	12.80	1.60	12.35	12.50	1.55
Bolivia 2008	12.41	12.50	1.63	12.23	12.40	1.63
Burkina Faso 2010	12.07	12.30	1.70	11.81	12.00	1.76
Burundi 2010	13.43	13.50	1.59	13.24	13.40	1.47
Cambodia 2010	12.35	12.40	1.28	11.97	12.00	1.47
Cambodia 2014	12.21	12.30	1.30	12.01	12.10	1.35
Cameroon 2004	11.96	12.10	1.70	12.20	12.30	1.74
Cameroon 2011	12.18	12.30	1.60	12.31	12.40	1.66
Congo 2005	11.59	11.70	1.51	11.51	11.60	1.48
Congo 2011-12	11.67	11.80	1.35	11.85	11.90	1.43
Congo DR 2007	11.93	12.00	1.70	11.81	11.90	1.84
Congo DR 2013-14	12.17	12.30	1.57	12.28	12.40	1.58
Cote d'Ivoire 2011-12	11.80	11.90	1.62	11.68	11.80	1.63
Egypt 2014	12.55	12.60	1.04	12.60	12.60	1.19
Ethiopia 2011	13.45	13.60	1.56	13.04	13.30	1.79
Ethiopia 2016	13.12	13.30	1.59	12.61	12.80	1.84
Gabon 2012	11.42	11.60	1.58	11.64	11.80	1.60
Gambia 2013	11.69	11.80	1.66	11.06	11.30	1.73
Ghana 2014	12.11	12.30	1.50	12.08	12.20	1.46
Guatemala 2014-15	13.31	13.40	1.36	13.31	13.40	1.45
Guinea 2005	11.87	12.00	1.69	11.74	11.80	1.72
Guinea 2012	12.07	12.20	1.50	11.75	11.90	1.67
Guyana 2009	12.23	12.40	1.50	12.32	12.50	1.60
Haiti 2005-06	11.84	12.10	1.85	12.14	12.40	1.81
Haiti 2012	11.68	11.80	1.61	12.01	12.20	1.57
Honduras 2005-06	13.07	13.20	1.36	13.13	13.20	1.42
Honduras 2011-12	13.12	13.20	1.34	13.28	13.40	1.36
India 2005-06	11.79	12.00	1.69	11.61	11.80	1.75
Jordan 2009	12.71	12.80	1.46	12.73	12.90	1.51
Jordan 2012	12.41	12.60	1.58	12.43	12.60	1.60
Kyrgyz Republic 2012	12.41	12.60	1.60	12.26	12.50	1.67
Lesotho 2009	12.80	13.10	1.88	12.89	13.10	1.68
Lesotho 2014	12.63	12.90	1.84	12.98	13.10	1.77
Malawi 2015-16	12.42	12.50	1.71	12.52	12.70	1.63
Mali 2012-13	12.03	12.20	1.58	11.67	11.80	1.63
Moldova 2005	12.67	12.80	1.34	12.46	12.60	1.38
Mozambique 2011	11.72	11.90	1.85	11.71	11.80	1.67
Myanmar 2015-16	12.08	12.20	1.47	12.03	12.10	1.54
Namibia 2013	13.14	13.30	1.63	13.03	13.20	1.59
Nepal 2006	12.53	12.60	1.55	12.43	12.60	1.55
Nepal 2011	12.63	12.80	1.54	12.55	12.60	1.53
Niger 2006	12.37	12.50	1.81	12.03	12.10	1.88
Niger 2012	12.16	12.30	1.56	12.03	12.20	1.61
Peru 2011	13.06	13.20	1.36	13.04	13.10	1.39
Peru 2012	13.01	13.10	1.32	12.92	13.00	1.35
Rwanda 2010	13.37	13.60	1.58	13.30	13.40	1.52
Rwanda 2014-15	13.17	13.30	1.47	13.08	13.20	1.51
ST and Principe 2008-09	12.00	12.10	1.55	12.23	12.30	1.48
Sierra Leone 2008	12.00	12.20	1.63	11.95	12.10	1.65
Sierra Leone 2013	12.23	12.30	1.58	11.86	12.00	1.56
Swaziland 2006-07	12.42	12.60	1.76	12.75	12.90	1.65
Tanzania 2010	11.95	12.10	1.76	12.17	12.30	1.71
Tanzania 2015-16	12.05	12.20	1.70	11.97	12.10	1.67
Timor-Leste 2009-10	12.76	12.90	1.40	12.80	12.90	1.41
Togo 2013-14	11.77	11.90	1.60	12.23	12.30	1.57
Uganda 2011	13.23	13.40	1.73	12.90	13.00	1.63
Yemen 2013	10.93	11.00	1.82	10.56	10.60	1.93
Zimbabwe 2010-11	12.59	12.80	1.84	12.79	13.00	1.82
Zimbabwe 2015	12.71	12.90	1.75	12.77	12.90	1.70

Note: Congo DR, Congo Democratic Republic; ST, Sao Tome; SD, Standard deviation; Hemoglobin adjusted for altitude and smoking prior to removing implausible values